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IN ALL THEIR DEPARTMENTS.

BY A COMMITTEE OF PRACTICAL SURVEYORS, ENGINEERS, AND ARCHITECTS, OF MUCH EXPERIENCE AND IN ACTIVE EMPLOYMENT

ROBERT MUDIE, LITERARY CONDUCTOR.

ELEMENTARY LESSONS

IN THE THREE PROFESSIONS, OR ANY OF THEM.

NO. IV.—NUMBERS. NO. 4.

Operations of extracting Roots.

As professional men have hardly ever to find the roots of any powers but the square and the cube, we shall confine our observations to them, and the observations shall be as few and simple as possible. When formerly treating on these subjects, we showed that the power of any number must, for each figure in it except the last one, consist of as many figures as the number of the exponent. Therefore, if we begin at the units of an integer number, and mark it off in periods of two figures each, the number of those periods will give us the number of figures in the square root; and if we in like manner divide it into periods of three figures, the number of these figures will be the same as that in the cube root; but this does not show us any one of the figures of which the root is actually composed; and it is of no consequence whether the left-hand period consists of one figure or more. If the power is a decimal number, the marking into periods must begin at the left hand, and in this case it is of no consequence how many figures the last period on the right may contain. This principle, as may at once be seen, is the same application of the numerical scale which runs through every arithmetical process. If the number is wholly decimals, and these do not amount to an entire period, the deficiency must be made up by a 0 or 0s; but nothing of this kind is necessary with the left-hand period of an integer number.

The periods, and consequently the number of figures in the roots, are seen by simple inspection; but there is another part of the process to be performed, namely, what those figures shall be, and this is a more difficult matter, or at all events a more tedious one; and in order that the operations may be properly understood, it is best to examine the composition of the powers in general terms, because then we can at once see all the combinations. Let then, $a+b$ represent any root consisting of more than one figure, in which b stands to a in the relation of the units to the figures on the left of them. In applying the principle of the extraction of roots, a means all the figures already found, and b the one which you are finding or wishing to find. When a figure is found it becomes part of a, and the succeeding one becomes b until the operation is concluded, or extended as far as may be thought necessary.

Let us find the square and cube of $a+b$ by simple multiplication, and then we shall see what combinations of the two parts of the roots enter into the power; and the converse of this will be our guide when the power is known and the root sought.

Write down $a+b$ as multiplicand, and again as multiplier; multiply them, and you have the square: multiply this by $a+b$, and you have the cube. In performing these operations, you are to bear in mind that b represents units, and that, consequently, no power of it can have 0s on the right, but must begin at the unit's figure. So also you are to bear in mind that a represents tens, or numbers higher in the scale, and therefore it, or any product of it, must have one figure on the right, the square must have two, the cube three, and so on.

But let us proceed to our multiplication:

$$\begin{array}{r} a+b \\ a+b \\ \hline a^2+ab \\ \quad ab+b^2 \\ \hline a^2+2ab+b^2 = \text{The square.} \\ \quad a+b \\ \hline a^3+2a^2b+ab^2 \\ \quad a^2b+2ab^2+b^3 \\ \hline a^3+3a^2b+3ab^2+b^3 = \text{The cube.} \end{array}$$

Examining these, we observe that, as the root consists of two distinct parts or terms, joined by +, so each power consists of one term more than the exponent,—the square of three, the cube of four; and if we repeated the multiplication so as to get higher powers, the number of terms in each of these would always be one more than the exponent. We may also perceive that the first or left-hand term of the power is simply that power of the first term of the root, and that the last term of the power is simply that power of the last term of the root; but that the intermediate terms consist of different factors, and are more complicated. They consist of products of the terms of the root, or the powers of these, together with certain numbers which arise in the operation, and which are called co-efficients, that is, "workers together" with the terms, because, although they are not made up of these, they enter into the compound term as factors. This, for instance, in the square, which has only one intermediate term, that is the product of the terms of the root multiplied by 2. In the cube, where there are two intermediate terms, the factors are the squares of each multiplied by the other one, and again by the numeral co-efficient 3.

Returning to the arithmetical consideration of the matter, applying the arithmetical scale, and bearing in mind that a means all the figures but the units, and b the unit's figure, we have the composition thus expressed:

First, of the square. The square of all the figures except the units, twice the product of all the other figures by the unit figure, and the square of the unit figure.

Secondly, for the cube. The cube of all the figures but the units, three times the square of all the other figures multiplied by the units, three times the other figures multiplied by the square of the unit figure, and the cube of the unit figure.

If numbers were substituted for a and b, or if the relation of them as explained is well understood, it will be seen that there should

be as many 0s in the numeral expression of each term separately as there are terms to the right of it, or, which is the same thing, as there are + es.

Thus, if we take the square and retain the letters, so as to make it perfectly general or applicable to all numbers, we have the following expressions for the three terms of the square :—

First term = a^2 00
Second term = 2 ab 0
Third term = b^2

In like manner, the four terms of the cube are thus expressed :—

First term = a^3 000
Second term = 3 a^2 b 00
Third term = 3 ab^2 0
Fourth term = b^3

The co-efficients may be multiplied by these 0s, which of course make 1 with the number of 0s after it, and these products may be made multipliers of the letters or of any figures that may be substituted for them. Thus the intermediate term of the square is twenty times the product of all the figures except the unit figure, by the unit figure. In the cube, the first intermediate term is 300 times the product of the square of all the figures except the unit figure, by that unit figure; and the second intermediate term is 30 times the product of all the figures but the units by the square of the units.

This analysis should be carefully attended to, because it contains both the processes for obtaining square roots and cube roots, and the principles upon which these processes are founded.

As either power is found by multiplying the root by itself, or involving it, the number of times that may be required, so the root may be found by reversing the operation, or undoing the multiplication. For the first figure of the root, there are no means of proceeding but trial and error; and by this means we find the greatest square or cube that can be subtracted from the left-hand period of the power. Having done so, we subtract this power from the period, and place its root for the first figure of the root sought; and then we annex the second period of the given power to the remainder, and out of the sum we find the second figure of the root.

SQUARE ROOT.

For the purpose of doing this, we must look back at our formula :—

For the square, it is

$$a^2 + 2\,ab + b^2;$$

but we have found a, the first figure, and subtracted its square from the given power or number, and so we may take a^2 from the formula, which will leave

$$2\,ab + b^2$$

This is the product of b, the figure we are seeking, and the divisor by which we must find it; and if we divide this by b, we have the divisor itself. To divide by b, is evidently nothing more than to diminish the exponent of b by 1 in every term. If b is a first power, or has 1 for exponent, this is not written, and b vanishes from the term altogether. Thus $2ab + b^2$ divided by b, gives us $2a + b$, as divisor for the square root.

But a stands to b in the relation of tens to units; and therefore the divisor becomes twice the figure already found, with the unit's place blank, to receive the figure we are finding.

Comparing this first part of the divisor with the dividend without the unit's figure, we get the figure of the root, or quotient, the same as we do in common division. Having got this figure, we write it in the quotient, or root, and complete the divisor by writing it there as the unit's figure. Then we multiply the completed divisor by the figure in the root, or quotient, subtract the product from the dividend, annex the next period of the given number to the remainder, and repeat the operation until there is no remainder, or till the root is as far extended as we think necessary.

It is evident that by this means we satisfy the conditions of the formula. That formula, for the complete square of the first and second figures of the root a and b, is

$$a^2 + 2\,ab + b^2,$$

First, we take away the square of the first figure, or a, and there remains

$$2ab + b^2:$$

Secondly, we divide this by b, which gives us the divisor,

$$2a + b,$$

of which b, the unit's figure, has to be found by trial. When we have found it, we complete the divisor, and multiply it by this figure, which gives us

$$2ab + b^2,$$

to be taken from the first and second periods of the given number. But a^2 was already taken from it; so that we have now taken away

$$a^2 + 2ab + b^2,$$

which is the square of the sum of any two figures, of which a stands in the relation of tens, and b in that of units.

But $a + b$ may be considered as one whole, as well as a or b, in the same manner that 24 is a whole as well as 20 or 4; and thus at every step of the operation, all the figures already found may be called a, and the figure we are finding b. From this analysis, we derive the

RULE FOR FINDING THE SQUARE ROOT, which is as follows:

1. Begin at the right hand of integers, and at the left of decimals; mark off into periods of two figures, and there will be as many figures in the root as there are periods.

2. Find the greatest possible square root of the left-hand period; write it as the first figure of the root sought; subtract its square from the first period, and annex the second period for a dividend.

3. Double the figure already found, and write it for a divisor, leaving the units blank.

4. Find how often this divisor is contained in the dividend to the left of the unit's figure, and place the number for the second figure of the root, and also in the unit's place of the divisor.

6. Multiply the whole divisor by this figure; subtract the product from the dividend, and annex the next period to the remainder. Repeat this operation as often as is necessary.

It will sometimes happen, that the product of the complete divisor by the quotient figure will be greater than the dividend. When such is the case, 0 must be written in the quotient, or root, and another period annexed to the dividend.

Surveyors, Engineers, and Architects have frequent occasion for finding square roots, and therefore all who aspire to those arts should make themselves well acquainted with the principles, and ready at the operations.

If there are integers in the power, the root is always less than the power; but if the power is all decimals, the root is greater.

The usual method of expressing the root, in terms of the power, is to place the radical sign $\surd$ over the power; and for other roots, the radical sign with the exponent over it. But fractional exponents are neater. Thus, $\surd 2$ and $2^{\frac{1}{2}}$ equally mean the square root of 2.

Example.—What is the relation between the square root of any number or quantity, and the square root of its half? It is 1 to the square root of ½, or, which is the same thing, of ·5; but ·5 is not a decimal period unless we annex 0 to it, and make it ·50, the square root of which is ·7 very nearly, as ·50 is only 1 greater than ·49, the square of ·7. Therefore, the proportion of the square root of any whole to that of its half, is 10 to 7; and, if we continue the operation, we find 1000 to 707 the next approximation; but the first is near enough for all ordinary purposes.

Example.—What is the difference in cost, between enclosing a square acre at 1*s.* 3*d.* a yard, and enclosing two square half acres at the same?

The square acre has 4 sides at 10; and the two square half acres 8 sides at 7; so that the proportion is 40 for the acre, and 56 for the half acre, which is 5 to 7, or the two half acres cost two fifths more than the whole acre. 4 times the square root of 4840, is the four sides of the acre; and from this, the prices and their difference are easily found.

CUBE ROOT.

It is not often that a professional man has to find a cube root; but as there are some cases connected with solid work in which it does occur, it should be in so far known.

The number of periods of three figures, counted from the right in integers, and the left in decimals, show how many figures should be in the root.

The root of the left-hand period must be found by trial, as in the square root, inserted in the root as the first figure, its cube subtracted from the period, and the next period annexed to the remainder for a dividend.

Then for the divisor:

The figure already found is a, and the one next to be found is b; and the complete cube of $a+b$ is

$$a^3+3a^2\,b+3\,ab^2+b^3.$$

Omit a^3; divide the remaining terms by b, and you have

$$3a^2+3ab+b^2=\text{the divisor—}$$

in which $3a^2$ is hundreds, $3ab$ tens, and b^2 units.

In the operation, each term must be found separately, and the places in the scale of numbers may be marked by 0s after the coefficients: thus—

1st term	=	$a^2\times 300$
2nd term	=	$3ab\times 30$
3rd term	=	b^2

Or, they may be expressed in words:

1st term, 300 times the square of the figure or figures already found.

2nd term, 30 times the product of the part already found by the figure you are finding.

3rd term, the square of the figure you are finding.

This is the divisor throughout the whole operation, how long soever it may be; and the only difference is, that an additional figure is found at every step, and the operation becomes more laborious.

In this, we need not translate the expressions into a formal rule, as they must be intelligible to every one who fully understands what has been stated respecting the formula for the square root.

If any number given as a power is composite, and has all its factors complete powers of the same degree, or exponent, then the number itself is a complete power, and its root is the same as the product of the roots of all its factors. But, if some of its factors are the same power, and others not, then the number itself is not a complete power; and though its root may be approximated to any degree of nearness, it cannot be found exactly.

Thus 4×9, or 36, is a square, and the root is 2×3, or 6. But 4×8, or 32, is not a square, because the factor 4 is a square, and the factor 8 is not. In like manner, 8×27, or 216, is a cube; and the root of it is 2×3, or 6; but 8×28 is not a cube.

The doctrine of roots and powers affords many examples of beautiful analysis; but they have more attraction for students of arithmetic than for students of the engineering arts, who use numbers only as a tool in their calculations.

SLIDING DOCK-GATES.

Sir,

Upon looking over Weale's catalogue a short time since, my eye was caught by the title of a pamphlet, descriptive of a new kind of lock-gates,* and as circumstances have rendered the subject peculiarly interesting to me, I immediately procured a copy; but was not a little surprised to find, on opening the plates, that the scheme was identical with that of a lock proposed for a part of this navigation, by Wm. Cubitt, Esq., Civil Engineer, in 1827, and I beg permission, through the medium of your pages, thus to claim for that gentleman the priority of invention, although M. Singel has received the gold medal from the King of Holland for the invention.

To enable you to appreciate for yourself the similarity of the designs, I forward you herewith, together with Mr. Singel's publication, the original set of plans made by myself, under the direction of Mr. Cubitt, for the lock at Mutford Bridge. This work was offered for public tender; the tender of a Mr. Green accepted, and the works commenced by driving cofferdams around the intended site. Upon opening the ground however, the substratum was found in places so weak as to render it necessary to alter the position of the lock. This alteration of position rendered it difficult to obtain convenient approaches to the two bridges (which the gates were also intended to form); and for this and other reasons the plan was abandoned, and a double lock, that is, a lock with gates pointing both ways, was built instead. I do not know whether you will consider the subject sufficiently interesting to your subscribers to induce you to give an engraving of Mr. Singel's design, but you will perhaps allow me to make a few observations as to the advantages of sliding gates, which have escaped Mr. Singel. These gates may, with very trifling additions, be made to serve as *bridges* across the locks; and their subserviency to this purpose was one main inducement for their use at the Mutford lock: a platform which covers the recess when the gates are closed, was jointed to the gate, and formed a gently rising approach to one end of the bridge; the machinery for moving the gate (or bridge) was so contrived as to lift the extreme end of this platform a height equal to its thickness, when it was moved upon its own wheels, upon rails adapted for the purpose.

The proposed lock was required to be placed in a narrow neck of land, which divides two lakes: along this narrow neck was a road, which it was necessary to accommodate across the lock. Now a

* Projet d'une nouvelle Construction de Portes d'écluse, appelées, "Portes à barrière." Par T. C. Singel, 1830.

swing bridge over the chamber of a lock is objectionable, from the necessity of its being kept open the whole time the vessel is in the lock. It is consequently usual to extend the walls of the lock so as to carry the bridge over clear of the chamber; but even this arrangement, when there is much traffic, causes a considerable stoppage to the road; but if, as in the proposed plan for the Mutford lock, sliding gates, both fitted as bridges, are used, it is clear that one of them *must always be passable.*

At the junction of canal navigation with tide water, it is frequently necessary to construct a terminal lock with gates pointing both ways. This was the case at the Mutford lock, and if we agree with Mr. Singel, that sliding gates possess any advantage for single locks, they must be doubly advantageous when superseding two pair of gates. In the gates for the Mutford lock sufficient liberty was intended in the *bearings of the wheels* to allow the gate to apply itself to either face of the stonework, as the pressure might require: in the section of Mr. Singel's gate is shown a raised platform under the gate, which appears to be closely embraced by the two lower bars of the gate, which would prevent such necessary lateral motion as would allow its closing against either face. Mr. Singel proposes culverts for the passage of the water from the lock, and as a means of scouring out the recess they might be useful. I cannot however, apprehend any danger to the gates by making slakers in them as proposed for Mutford; indeed, these gates appear to me particularly adapted for carrying such drawgates as would answer, were they required for scouring sluices.

The planting of Mr. Singel's gate is injudicious, inasmuch as it is only adapted to resist the pressure of the water, by the adhesion of the nails. Some means of relieving the rails of some of the weight of the gate is desirable, but one or more caissons, provided with pumps, would be better than empty casks for this purpose.

I am, Sir,

Your obedient servant,

Lowestoff, May, 1841. GEORGE EDWARDS.

DESIGN for a new construction of Lock Gates, called Sliding Gates, uniting with all the advantages possessed by the present usual means of opening and closing canals, that of being able to give to locks such a width as is required by the build of vessels of war, or of commerce, and more especially of steam vessels; by T. C. Singel, Hydraulic Engineer to the Banks of Poland, and lately in the service of "The Waterstaat" of Holland, for which invention His Majesty the King of Holland has presented to him the gold medal, with two plans, printed and lithographed at Gorcum. G. H. Horneer, 1839.

DESIGN V.

The construction which I propose will appear, to scientific men more especially, applicable to maritime ports, to docks for building or refitting, and to mercantile docks, the closing of which cannot be effected otherwise than by floating gates, and which exceed fifty feet opening.

Moreover, the careful examination of this construction will no doubt make it appear that it is equally applicable to navigable canals at the points of their separation, where the maintenance of the summit level depends more or less upon the supply of rain, often interrupted by droughts, as in the Canal du Midi, or supplied by extensive steam machinery, as the Rochdale canal, between Manchester and Halifax*; for it is easy to observe, that locks with "sliding gates" do not require so great length, and consequently so great a quantity of water, as those with pointing gates.*

Engineers will also observe, that they will be able to diminish the number of locks by at least two-thirds; for whilst the strength of pointing gates depends upon their small height, which rarely exceeds seven feet, the sliding gate admits of any height engineers may require, without fear of their strength being insufficient.

PLAN, ELEVATION, AND SECTION.

The design shows a sluice, 100 Rhenish feet wide between the walls, intended for a seaport, the gates being adapted to the flow of the tides; in other cases, the length, width, and height, may be suited to the locality and necessities of the country.

It will be observed by the plan, that the whole length of the lock is an inverted arch, with the exception of the small part occupied by the gates, affording great strength of construction, an advantage not obtained in locks with pointing gates, where the platform presents a large horizontal surface for the movement of the gates. The difficulty of securing such large horizontal surfaces in the chamber of a lock from rising, is well known to engineers.

On the other hand, the horizontal part of the floor occupied by the sliding gates, not being more than a third of that required by pointing gates, will offer much greater strength, as will be observed on examining the section.

It will doubtless be objected that the amount of masonry required in locks with sliding gates, will be much greater than in locks with pointing gates.

When sliding gates are used for sea docks, where pointed gates cannot be used on account of the too great width of the opening, this objection does not obtain: the only comparison to be made, then, is between sliding gates and the floating gates used to present.

As regards navigable canals, the cost of that part of the masonry saved by the shortening of the lock must be calculated, and then it is to be considered whether the advantages of the very great solidity of the platform, and the small expense of water, will not be equivalent to the additional cost of the chambers which is objected.

The celebrated engineer, Mr. S. Blanken, "Inspecteur-général des travaux hydrauliques en Hollande," in his pamphlet in Dutch, (1808), on *balance gates*, thus expresses himself on the subject of *floating gates*:—"The closing of docks by means of floating gates, requires much greater stillness of the water than ordinary gates, whilst the gate settles perpendicularly in the grooves, and is not able to resist any movement of the waves, or of a current; to seat itself on the floor of the dock, it should fit exactly in its groove, a reason which renders this means of closing little applicable to locks in harbours exposed to the sea, or which have before them a large basin, for it often occurs that it is not sufficiently calm to manage the floating gates. Even admitting circumstances to be most favourable, as in a perfect calm, it is only possible to open or shut a single time in twelve hours, whilst it is high water, to give a passage to the vessel.

SECTION.

It is here shown that the platform for sliding gates offers greater strength than that of pointing gates: to strengthen the horizontal part of the platform of a lock founded upon piles, there are placed

* Vide Charles Dupin, "Commercial Power of Great Britain," page 180.

* The length of a lock with pointing gates, depends upon the length of the vessel added to the width of one of the gates, whilst a lock with sliding gates requires to be only the length of the vessel.

over the planting, timbers called main cross-pieces, which are secured by their extremities 5 or 4 feet under the walls; and it appears that this construction, in locks not more than 50 feet wide, as in those with pointing gates, offers sufficient resistance to the pressure of the earth. But in those which exceed this, or which are double this width, it is necessary to use another mode of construction.

In the section, which shows the arrangement of a gate for a lock 100 feet wide, the hydrostatic pressure does not act on a surface more than 33 feet wide, for the main cross pieces are placed across the opening, and 3 or 4 feet of their ends are built into the masonry of the floor and chamber.

SLIDING GATE.

The gate is a framing of carpentry, the thickness of which is proportionate to the width of the lock, and should equal one-fourth of the width of the opening; whence will result the advantage of the opposite angle being maintained at 20°, as usual in pointing gates.

Each trussed frame, to the number of 8 altogether, in the height, is equivalent to the bars of pointing gates.

The cross pieces, which rest upon the bars, are intended to resist the pressure of water upon the gate; the object of this kind of gate being to stop the water both ways, either from that of the canal, or that of the sea, the frames oppose one another, representing two pair of pointing gates, one for the flood, the other for the ebb.

The frames which we have mentioned as placed above one another to the number of eight, are braced and supported at 4 feet distance, by the four uprights, which being also connected by the cross pieces, complete the quadrangular form of the gate.

In the interior of this framing are fixed diagonal cross pieces, strengthening the whole, and preventing any deviation from the perpendicular, which the pressure of the water would otherwise cause.

It is desirable to secure all the angles of junction of the carpentry by Ts and Ls of iron, fastened by screw bolts.

The skeleton of the gate, being put up as above, is to be covered with planting on the interior of the two principal sides, the ends remaining open to afford a passage to the water from the culvert, through the interior of the gate.

At the lower part, and in the bottom of the gate, are fixed four beams, two and two, between which, wheels of bell metal are solidly attached.

And, as two iron rails are secured to the side of the lock which has to carry the gate, it follows that the whole of the gate can be put in motion as a carriage upon a railway.

CULVERTS BUILT IN THE WALLS FOR MANŒUVERING THE GATES.

There are two culverts to the two sides of the lock, intended for the use of the gate,—that is, for obtaining the same height of water within and without.

Two essential motives suggest the employment of these culverts.

First.—To establish the level of the water before opening the lock. Slakers might be made through the gate themselves, as in pointing gates; but as such slakers could not but injure the strength of the framework, by the shaking caused by the rapidity of currents through, it is thought preferable to adopt the use of culverts.

Secondly.—These lateral currents, as they can at pleasure be directed through the whole length of the gate, will act as scouring sluices, adapted to clear the floor of the chamber, and of the lock, of all the deposits which can be brought in and left by the tides.

MANAGEMENT OF THE GATE.

The movement of the gate for opening or closing the lock is effected by means of a capstan, shown in the plan, such as is used for pointing gates. Suppose a vessel from sea requires to enter the canal, the gate being in its chamber, and the water in the lock level with that of the sea: the vessel is drawn into the lock, when by means of the capstan the gate is drawn across the opening to close in the vessel. This done, the slakers P Q R are to be opened; the water passing from the chamber through the interior of the gates establishes a level between the lock and the canal, when the (other) gate is drawn back into its chamber to afford a passage to the vessel.

It may here be remarked, that in the plan of the gate hollow cylinders are shown, inserted in the framework.

It is easy to conceive that this gate, constructed of heavy squared-oak timber, strongly ironed at the angles, and provided with metal wheels, will be of much greater specific gravity than water.

To facilitate therefore the working of the capstan, and to favour the rails and the wheels, empty casks are inserted in the openings of the framework, which will diminish by so much the weight of the gate, and render its movement easier than that of pointing gates.

It is not necessary here to expatiate upon the construction of the chambers, which are shown in the plan, but it is recommended to give them some curvature, which will prevent the entrance of any extraneous substance which might damage or obstruct the railways.

NOTE BY THE EDITOR.

Mr. Cubitt informs us, that the statement respecting his invention of the sliding dock gate at the time specified, is strictly and literally true. He contrived the gate for the purpose of obtaining such breadth in the lock as should admit ships of some burden. The plans which we have in our possession were prepared by Mr. Edwards. According to the directions of Mr. Cubitt, contracts were advertised for, and one was accepted; but those in the management changed their mind, from some cause we need not state, and Mr. Cubitt's invention was never executed, or published in any other way than by the advertisements for the contract. Therefore, Mr. Cubitt is of opinion, that the most likely construction to be put upon this matter is, that Mr. Singel has re-invented the gate without the slightest knowledge of its having been previously invented by Mr. Cubitt. Mr. C. farther mentions, that double inventions of this kind are very common in civil engineering, and that he has known many of them, some on this very subject of dock gates. We can readily understand why this should be the case, and if two engineers, who equally well understand their business, meet with the same difficulty, that they should resort to the very same means of overcoming it.

This gate is a clever invention, and one which must be of great service in all cases where it is applicable; but, except in such situations as that for which Mr. Cubitt contrived it, and there are very few of them, it is not suitable for the system of canal navigation in England. The English canals are for the most part what is called single, that is, seven feet of clear water way-from the slopes

of the banks; but there are a few which are double, or fourteen feet wide. Upon most lines of canal in England, the economy of water is a very important matter; and, therefore, the lock is made as narrow as will admit free motion in the barge. Very little care is taken to provide a greater supply of water, although tanks and reservoirs of sufficient size in the uppermost depressions of the hills would completely answer this purpose, and admit of the working of canals over summit levels, where they cannot now be worked at all, or must be worked by pumping, or some other expensive means. Of this expense, there is an example in the Grand Junction Canal, near Braunston; and yet the quantity of rain which falls on the neighbouring heights is so great, that if it were conserved in reservoirs, and not allowed to run to waste and inundate the country in the floods, there is as much of it as would work several canals of the same size and traffic as the Grand Junction. Another instance of great expense in working, occurs on the Kennet and Avon canal, near Devizes; and we question whether, when the Great Western Railway comes into full play for the carriage of goods, it may not cause the canal, which is not a very profitable concern at present, to be wholly abandoned. The Basingstoke Canal is an instance where want of water completely prevents the passage of a few miles of summit level, between Basingstoke and the eastern branch of the Test. This place is situated near high chalk downs, upon which there falls a great deal of rain, and the rain runs off very suddenly in floods. Therefore, the conservation of it in tanks and reservoirs would be an important matter, because, if this summit level could be passed, a water carriage might be established between London and Southampton. It is true, that the line of this canal is very circuitous, and the voyage would be tedious, as compared with the railroad; but the preservation of the water would answer other purposes besides the mere working of the canal.

These instances will serve to show that, unless in very favourable situations, the canals of England are a wretched system, and do no credit to their respective engineers. They are made, however, and most of them belong to companies established by act of parliament, so that the improvement of them, though such improvement were desirable, would be a very difficult matter.

In Holland and the Netherlands, the case is very different: there is no want of water in any situation, or at any season, and most of the lines, for long distances, lie upon dead levels. Such canals either are, or easily could be, rendered available for ship navigation; and, wherever a lock were required, a gate upon Mr. Cubitt's principle would be found the most durable, the closest, and the most easily worked. We need not wonder, therefore, that Mr. Singel should have been partial to this kind of gate, because it is just what is wanted in his country; and that he should have hit upon it, shows that he is well qualified for his office.

Whether canals shall ever again come into vogue in this country, is a question which we are unable to decide. When first constructed, and the Duke of Bridgewater gained so much money by his canal, there was a mania for works of this sort, without much regard to the fitness of the ground for them, the chance of trade, or any of the other circumstances upon which the value and profits of canals depend. But, though folks were seized with a canal mania, the rabidity does not seem to have been nearly so general nor so fierce as it has been in the case of the railways; and though the chance, nay, the certainty, is, that a great deal more capital will be sunk and lost on the railways, the canals generally have not been profitable; and this is against any improvement of the system.

DOMESTIC ARCHITECTURE IN ENGLAND.

It has often been boasted of by Englishmen, and admitted by foreigners, and indeed it cannot be denied, that, speaking generally, there are more of the real and substantial comforts of life in the houses and establishments of the English than in the dwellings of any other nation under the canopy of heaven. According to the fiction of law, an Englishman's house is invested with a protecting property, which no other man's house possesses. It is, or is called, his "castle," into which the law has no power to enter in matters of civil process. The law, indeed, is a crafty enemy, and can find ways and means of rendering this boasted protection of no avail; but still it is said to exist, and this is sufficient ground for boasting.

Thus, in the ordinary shelter afforded by a house from the inclemency of the weather, the pleasure which it affords, or should afford, by bringing all the family together, the substantial comforts, and this vaunted protection, the Englishman's house should be dearer to him than any other of his possessions; and if he is to display a taste for any thing, is that wherein it ought to be displayed.

It appears too, on the first blush of the matter, that the Englishman is more free to do this than the inhabitant of any other country; for the people in themselves, personally, or by their representatives, have such a control, that no other party within the realm can expend public money without their sanction. They prevent public works from being executed in such numbers and of such styles as accord with the general wealth and grandeur of the country. Whatever work is done, even for the public accommodation, and whether it is more general or more local, must have the sanction of the Commons' House of Parliament, who are or should be the representatives of the people. Now, if the people are thus powerful in these matters, and the conservators of taste as well as of finance, it is but natural to suppose that they ought to display a great deal of taste in their dwelling-houses, and evince, by the style of these, the title which they have to rule the nation in point of taste as well as of expenditure.

Yet, strange and anomalous as it may appear, Englishmen not only display no taste in their dwelling-houses, but there is scarcely a house in the country above the merest hovel, which is a bonâ fide English house: there is indeed a fantastic, incongruous, and sometimes very absurd and incommodious style, which is called Elizabethan, and supposed to be English. But it is not so in fact. The groundwork of it is Italian, sometimes mixed with Flemish, and sometimes with a sort of incongruous matter, of which it is not easy to tell the origin.

Now, why should this be the case? Englishmen, taking the average even of the middle classes, can better afford to build houses than any other people; they have the very foremost of workmen in all trades; and they ought to have a great deal of taste. But, notwithstanding all this, there is not an English style of dwelling house. We have cathedrals and churches, some of them in the finest style of the middle ages, when architecture was the immediate subject of the patronage of kings, and gave scope to the talents of the foremost men in the church. So also we have fortalices and castles, or their remains, which once were the strong-holds of barons, who despised all law and all authority; and if these structures had not much architectural magnificence, they, or their ruins, show that they had abundant magnitude. Externally, they are

tasteless even to ugliness, and internally, with the exception of the public halls,—and their size is their chief recommendation,—they are most inconvenient. This bad taste, or rather want of taste, has come down to our own times; so that with the exception of some rare instances in which some eminent architect has been called in, the dwellings of our wealthy men are absolutely a disgrace.

In the vicinity of the metropolis, where one would expect better things, because the best architects are at hand, and the parties can afford to call them in, the buildings are quite ludicrous; so much so, that Cockney Architecture has become a common bye-word. It is much the same, whether those dwellings are single villas or mansions, or arranged in streets, terraces, or squares; for wherever they are, they carry their ugliness along with them. In the majority of cases, too, where tasteless builders have to collect the parts of the structure from all the winds of heaven, and heap them together in the best way they can, that which is supposed to be ornament, is in truth deformity. The house, if ornamented in their way, is emblematical of a shop or bazaar, in which something appears to please all tastes, how much soever these tastes may vary from each other. The accumulator looks over books of designs, and sees what he considers one pretty bit here, and another there; and as he would like to make use of them all, he produces the strangest compound that can well be imagined. We have, for instance, Egyptian sphinxes upon the blocking of a Roman front or gateway, vases on the top of a high wall where nobody can get at them, and a thousand other absurdities.

Then, when the external elevation is settled, the prime puzzle of the matter remains, namely, how to adapt this to the internal arrangement, or rather how to adapt the internal arrangement to this. Some of the windows must be made sham ones, because they fall on the ends of partitions, and on other places where they are not wanted; and others are placed near the corners of rooms, and throw a mass of light upon the stove, as if placed there for the very purpose of extinguishing the fire. Again, one room has a continual trade-wind setting from the doorway to the chimneys, so that people sitting near the fire in winter, are chilled on the one side, and roasted on the other. Others again, have no air in them except what occasionally comes down the chimney, and scatters the smoke and soot all through the room. In fact, it would be endless to enumerate all the absurdities that are produced by these attempts to fit a house to a front, on the part of a man that knows very little either of the one or the other. Why, again we ask, is there not an English style of domestic architecture, worthy of the nation? This question is very easily answered. Up to a very recent period, and, generally speaking, even now, those who build houses have neither discrimination to find out an architect of taste, nor liberality to pay him as he ought to be paid. The consequence is, that there is a want of this sort of taste in the country, for men will not generally devote their time and their labour to that which has no chance of paying them. An architect of taste must be studying long, before he begins to practise; his studying is expensive, he must have a costly library, and much time and thought are required for the composition of a good design. People will not in general pay for these, therefore they do not get them; domestic buildings are committed to inferior men, and hence the want of taste, and the substitution of incongruity and absurdity.

The following article was sent to us as a review, and it is so in reality; but it is so closely connected with this article, and each of them is so much calculated to establish what is said in the other, that we have preferred placing them in juxtaposition. Improper writing, purporting to be descriptive of architectural subjects, is at once the effect of the deficiency of good architectural taste, and the cause of the extending and continuing of this deficiency. Of Mr. Britton, or his works, or the sacrifices he has made in the cause of literature, we know or care very little. We have looked into some printed pages with his name prefixed to them; and we really considered them as more suited for burnt offerings on the altar of Dulness, than any other printed pages we ever met with. The gentleman who sent us the article possesses unquestioned knowledge and strict veracity, and would, we have no doubt, personally defend his critical remarks.

ILLUSTRATIVE DESCRIPTION OF DOMESTIC ARCHITECTURE.

Graphic Illustrations and Historical and Descriptive Accounts of Toddington, Gloucestershire, the seat of Lord Sudeley. By John Britton, F.S.A. &c. &c. &c. 4to. London.

When we say that, of the forty-six pages composing the letter-press of this volume, exclusive of the sixteen occupied by dedication and preface, only eight are devoted to any description of the building, the question naturally becomes, How are the rest filled up? Chiefly, we reply, with that garrulous and querulous, twaddling and egotistical stuff, in which Mr. Britton is notoriously prone to indulge. His querulousness is not the least of his peculiarities, for he has, in more than one instance, obtruded his own private affairs on the public in a very uncalled-for manner; and now, after giving us to understand, in the preface to a former work, that he had derived scarcely any profits from his various literary speculations, he here talks of his having been involved in consequence of a connection with an unfortunate railway company, and thereby "lost nearly the whole savings arising from fifty years of literary labour!" Such confessions are not only uncalled for, but, in this instance, contradictory to each other; for it is now evident, that he either complained rather causelessly before, and wished to pass for a martyr in the cause of literature, or else that he has not lost much by his railroad speculations—certainly not more than a good many others who have ventured in the same lottery. Nor is it we who go out of course to mention such things, but Mr. Britton himself, who is always talking of such personal matters in his books.

Whether we ought to include ourselves among those critics who have indulged in envious and malevolent strictures on his publications, we know not: at all events, there are others, besides ourselves, it seems, who do not hold John Britton to be quite so great an ornament to literature as he would fain make the world believe. We strongly suspect, moreover, that though he represents himself as having been very hardly and ungenerously dealt with, it would be found, upon inquiry, that he himself has not invariably acted with generosity, or even justice, towards a good many other persons. Most unquestionably, he has generally contrived to take the lion's share of fame to himself, and has, on more than one occasion, talked in a very big strain of what he has done for art, and of the talented artists he has brought before the public, forgetting that the relative position between the latter and himself ought rather to be reversed; because, in reality, it was they who buoyed their *patron* up, and kept him and his books afloat. Such men as Mackenzie and Cattermole could have dispensed with Mr. Britton's

patronage far more easily than he could have got on without their assistance. We do not say that there was any thing at all discreditable in Mr. B.'s consulting his own interest in such engagements; but it becomes absolutely nauseous and hypocritical in him, when he babbles, as he frequently has done, as if all his undertakings had invariably had no other object in view than that of promoting the interests of art and artists, and serving the public. Mr. Gammon —Mr. Britton, we mean, should really be a little discreet, because, although a good many of the "enlightened public" can be gulled easily enough by such arrant fudge, it is not every one who is to be imposed upon by it.

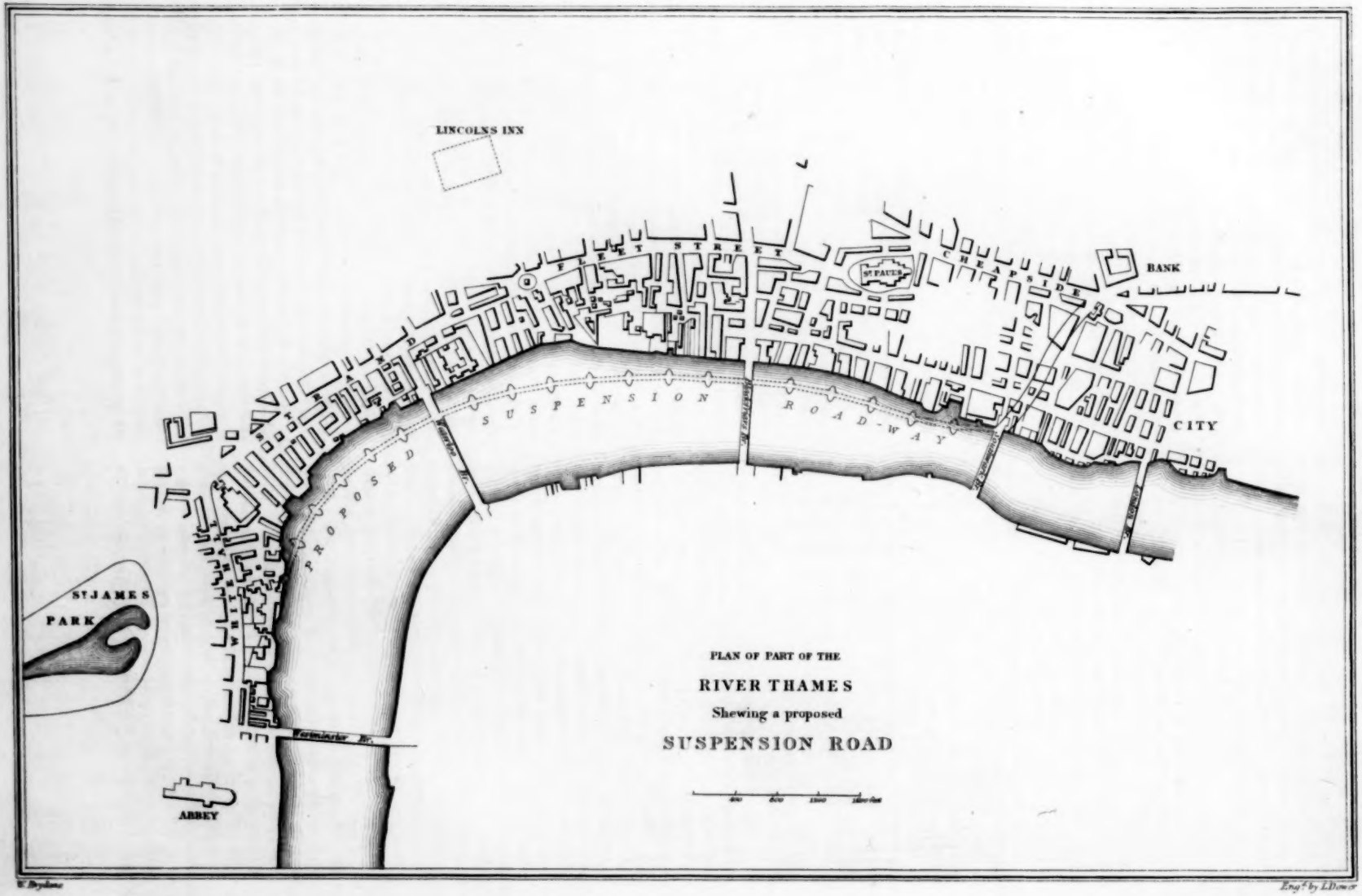
All this, we are well aware, has nothing whatever to do with Lord Sudeley's mansion at Toddington; but the same may be said of the book itself; and, at any rate, let whoever else may, Mr. Britton cannot complain of our indulging in idle irrelevant remarks, when his own volume affords us sufficient precedent.

There is a proverb touching cooks and meat, that would not be inapplicable on the present occasion; for we certainly do not think that the noble amateur-architect's work has been handsomely treated, or has had justice done it, either in the literary or graphic descriptions. The former, in fact, amounts to very little more than what can be understood from the engravings. There is scarcely any thing whatever to furnish additional explanation as to the numerous circumstances in regard to which we are now left altogether in the dark; and nothing in the shape of critical comment and remark. Consequently, we learn no more than can be gathered from the drawings themselves. These last are twenty-nine in number; therefore, it would seem, they would serve to describe and explain the whole structure tolerably clearly, and satisfactorily. Such, however, is by no means the case. There is not even a single geometrical elevation of any one of the fronts of the house, consequently, it is quite impossible to judge very accurately of the exterior details, or of the actual heights, of the different parts of the building; neither is there any plan of the upper, or chamber floor, though the arrangement of it must differ considerably from that of the ground floor; and though, for want of one, we are now quite at a loss to understand whether the upper part of what is called the chapel wing is actually appropriated to the purpose of a chapel, as its external appearance indicates, or not. All the more strange, therefore, is it, that this doubt should not have been removed, by explicit information as to that point in the letter-press.

The omissions, as to sections, are equally strange and provoking. There is only a single drawing of the kind, namely, one through the staircase; but it does not inform us whether there is any chamber or room of any kind over it in the upper part of the tower, although we must presume such to be the case; nor here, again, does the description afford the slightest information. Even a single general section from north to south, through the vestibule, inner court, staircase-tower, and dining-room, would have furnished some explanation now altogether wanting; but, from the very first glance at the ground plan, it is evident that several others would be requisite, in order to enable us to judge at all correctly of the interior of the mansion generally; therefore, if a greater number of plates could not be afforded, it would have been better to omit some of the subjects now represented—such for instance as the view of the kitchen, and the chimney pieces, and other geometrical elevations of the rooms shewn in the perspective drawings. At present there is a great deal which we are left to guess at as well as we can; among other things, for instance, whether the walls of any of the apartments here shown are coloured, and if so, what is their colour, and that of the furniture. Whether the furniture itself—that is, the chairs, tables, &c., be actually copied or put in arbitrarily by the draughtsman, we pretend not to say, but should rather suspect the latter to be the case; or if not, we cannot say much for the taste displayed in the selection of it. There seems to have been no attempt whatever to keep up any sort of consistency between the furniture and the architecture, or the furniture of one room and that of another. While that of the dining room is altogether modern in character, perfectly simple, and of Grecian contour, that of the drawing and music rooms is—as here represented at least—most extravagantly uncouth, barbarous, and gimcrack—positively hideous. Such trifling inconsistencies and drawbacks, however, do not abate Mr. B.'s admiration, such as it is, a single jot. What observations he does make are all according to the approved George-Robins principle,—fulsome, florid, oily, unctuous; and all is *couleur de rose*. Yet, if he is lavish of his commendation, it is not worth having, for it is of an exceedingly vague, feeble, fumbling sort: it is evident enough that he is all the while afraid, on the one hand, of not spreading it on thick enough, and on the other, of committing himself. That he does not know when to praise is evident enough, because he has passed over some of the very best points of the internal arrangement and design, instead of dwelling upon them at some length, as he very properly might have done. There are, again, other parts of the plan, which we consider decidedly objectionable, for instance, the awkward communication between the dining-room and offices, the great distance from the kitchen, the dark passage through which the servants must reach the dining-room, the want—all the more requisite under such circumstances—of a contiguous *piece de service*, as a serving and clearing room; and though last not least, the absence of a sideboard alcove in the dining-room itself, a feature which adds so much to the character of such an apartment, and of which so much might have been made in the style here followed. We should say that the plan would be materially improved by altering the situation of the dining-room, removing it to the south-east angle next the offices, where the private library and study are now placed. This would, of course, render several other alterations indispensable, but we conceive that they might be made to conduce in no small degree to the convenience and beauty of the whole arrangement.

We are further of opinion, that if Mr. Britton himself had removed all the tables of pedigrees out of his book, they would never have been missed, for *tables* of that kind are certainly odd kind of furniture in an architectural work. If those *tables* might have been very properly dispensed with, so too might the *plates* have been considerably better than they now are, for not only are they coarsely executed, but in some instances very incorrect as to perspective and drawing.

We have said nothing of the preface to the volume, though it is a most notable specimen of what its author considers very philosophical writing, but what we hold to be most arrant *maudlin*, pitiful, mean, despicable whining, the plain English of which is, John Britton, F. S. A. &c., &c., &c., deeply laments that, as a mere *trade*, literature is not quite so certain, nor so profitable a one, as many others! After this, it is easy enough to guess what kind of devotedness our "glorious John" feels for literary pursuits and studies, and in what degree he actually resembles the enthusiastic scholar Petrarch, to whom, upon one memorable occasion, he was so besotted as to compare himself.



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SUSPENSION ROADWAY ALONG THE THAMES,

FROM WHITEHALL TO SOUTHWARK BRIDGE.

With a Plan.

We give in this number a plan of the proposed roadway along the Thames, the project of which was suggested by a correspondent in our last number; and believing this to be an excellent project in itself, and far superior to and more practicable than any of the promenades with architectural decorations that have been suggested, we return to the subject, and state such particulars as we have collected; and we hope, in a future number, to give a pretty close approximation to the method of construction, and the cost of all the parts.

The plan will show the extent, the direction, and the terminations of this suspension road, from which the public, and more especially those interested, will be enabled to judge for themselves. The whole line is about 9,000 feet in length; and, if we allow for the piers, and a projecting landing-place at Whitehall, the clear waterway of the arches may be taken at 8,000 feet. Blackfriars and Waterloo bridges divide this into three parts; and 20 arches will suffice, and adapt themselves to the situation. Each arch will be 400 feet in span; and there will be 6 between Southwark and Blackfriars, 8 between Blackfriars and Waterloo, and 6 between Waterloo and the terminus at Whitehall. These arches will be all equal in span, in height, and in appearance; and, as there is little difference between the heights of the bridge roadways, or between them and this roadway, it will be very nearly a perfect level for its whole length. It is purposed to make the piers of granite up to a given height, and to fix a strong cast-iron framing to the top of the pier, in order to attach the chains of the arches, one set to the one side, the other set to the other. The piers to be of dressed granite throughout; dovetailed, joggled, trenailed, and grouted with the best mortar; and thus they will bear to be of very small dimensions. The iron standards for attaching the chains to form a triangle at each pair of chains, with a tiebeam at top; and they may be fastened to the piers by strong iron bolts, let far into the granite, with screws and nuts at their upper extremities. The chains to be only two in number; to be as wide apart as the breadth of the carriage-way, and the roadways at the sides to be supported by brackets from below, strongly fixed to the piers and to the roadway between these, but passing outside the triangles which support the chains. The chains to be tapered both ways to a single link or bar at the middle, and braced up to a considerable height above the catenary, which will prevent lateral vibration and disturbance of the roadway.

By being formed in this manner, the chains will not require much more than half the iron which otherwise would be necessary, and the principal weight of this would be thrown toward the point of support. The bridge would thus be made much lighter, and at the same time it would be stronger and less liable to be affected by the wind. The large span of the arches, and the small diameter of the piers, would also give free passage, and persons using the bridge would not be annoyed by those interrupted gales which come so fiercely over the parapets of the windward side, in a common bridge. As each arch would be a separate bridge, excepting the mere fact of its abutting on the piers of the adjoining ones, any direction which were most convenient could be given to the general line. It is desirable that this line should abut on a pier of each of the bridges that it crosses; that these piers should be as near to the London side of the river as possible, so as not to interfere with the barges and barge navigations at the wharfs; and any angle which would occur in straight lines from bridge to bridge, could be parted along the line by the position of the piers.

There is another reason for keeping as near the London side as possible: much of the beach there is hard gravel to the surface, and the rest is of the same material overlaid with a thin coating of silt.

In consequence of this, scarcely any piling will be necessary; for the foundations of the piers could be laid on platforms; these platforms would not require any great depth, and many of the foundations would be above the low-water line, and almost all of them very near it. These circumstances would render the building comparatively cheap; the taper chains would do the same for the arches; and, considering its great length, it might be made one of the cheapest structures that ever was erected. It would also be an exceedingly convenient one, and might be made highly ornamental. It would only require to make an elegant street from Southwark bridge to the Mansion House; and trim up the buildings at the openings there in accordance with it. A beautiful artistical elevation, and one which could be seen from very advantageous points of view, might be erected between the termination of this street and Cheapside, and the whole line of the street, if formed into a curve of contrary flexure, and of sufficient width, would give scope for some better taste in shop-architecture than is yet to be met with in the streets of London. Regent Street is gingerbread; the new streets in the city are heavy, dull, and Smirkish; and all together the London shops, though with costly windows, and abundantly stocked, are tame and commonplace. It is true that, in a front here and there, there is some attempt at architectural display; but then this seldom gets higher than the shop itself; it gives the street a piebald and patched appearance. Generally speaking, the buildings in a line are either too like each other, or too dissimilar. When houses are in continuous rows, whether in the City itself, or in suburban squares or terraces, and whether intended for places of residence or places of business, there should be a dissimilarity in the parts, and a union of the whole. The line should be divided into blocks or sections, of such extent as that the eye could perceive a whole block at a view. Each block, too, should be a perfect architectural composition, such as could stand alone in a park, if that were necessary; but still there should be a harmony of these separate blocks, and a union of the whole, which should make the line one continuous architectural subject, at least from one cross street to another. This arrangement, as to blocks, would give a great deal both of beauty and variety to the whole façade, and it might be carried into effect without the sacrifice of any room. In such a part of the city, there would be wholesale apartments, show rooms, and offices of a superior order upon the upper floors. These would require separate entrances and staircases; and the divisions of the blocks would answer well for them.

In short, if this street were made as it ought to be, it would draw the very first shop and office business in the metropolis; and the increase of rent above what the houses on the site yield at present, would more than cover the expense,—that is, would render the ground rents very large annuities over and above whatever premiums might be obtained for the houses. It may perhaps appear to some, that we have dwelt too long and too minutely upon this street, which is only an adjunct of the suspension roadway; but it is so essential an adjunct, that the one would not be perfect without the

other. The facility of reaching the Bank of England and the other public offices of the City, would make the roadway a great thoroughfare for private carriages, equestrians, and foot-passengers; and, as the getting of money is the main object which brings the fashionables of the West End to the City, they would lay out a considerable fraction of it in this street. At present, there is no very eligible street for fashionable customers. Bond Street has fallen into neglect, and Regent Street never was, and never will be, anything but second rate—another Oxford Street as it were; and, though a shop here and there may be elaborately decorated, it will no more attract the fashionables than would a gaudy gin palace in a low neighbourhood. With some exceptions, therefore, and they are few and far between, there is not a succession of shops to the westward of Charing Cross, to which people of fashion can resort. One cause, and a very obvious cause, of this is, the building of the streets, crescents, and squares of first-rate houses, between Buckingham Gardens and Sloane Street. There the people of fashion escape from low neighbourhoods, ill-conducted idlers in the streets, and all the abominations of crowded thoroughfares. On this account, the first-rate houses in that quarter are bought or let as soon as they are erected; and what used to be the west end of the town has now veered round to the south-west. The natural thoroughfare whereby these fashionables enter Westminster, is the Birds Cage Walk, which is open for carriages all the year round. From it, Great George Street and Parliament Street soon bring them to the government offices at Whitehall, and to what has been proposed to be the western terminus of this roadway. Those who live farther to the north would have a little way to turn at Charing Cross, but still this would be their best, easiest, and most pleasant line of intercourse with the city. In fact, the movement of the population to the south-western district, which is at once warm, quiet, dry, and consequently healthy, forces the notion of such a roadway as this upon even the most casual observer. The Holborn line never was, and never will be, a favourite with the fashionables, and one might as soon expect to find a nobleman's family carriage on Salisbury plain, as anywhere upon this line, long as it is. If the contemplated bridge is erected, so as to take away the hills, the street might be more safe for omnibuses and cabs, but that would not bring the fashionables into it. If the New Road, as it is called, from Paddington, all the way to the Bank, is not worse, as a fashionable thoroughfare, than the Holborn line, it is certainly not better. It is long, vulgar, and ugly; and there are no sights to be seen along its weary length, except disagreeable or revolting ones. The streets on the Surrey side of the river are little better in themselves; and, unless a very long and very uninviting circuit is taken, the terminus is at Blackfriars Bridge; and the landing at the Farringdon end of Fleet Street is at one of the most annoyingly crowded in the city.

Therefore, three of the thoroughfares between the West End and the City are inadmissible on account of their character; and there is one which after the others is "Hobson's choice." This is the line of the Strand, Fleet Street, Ludgate Hill and Street, St. Paul's Churchyard, and Cheapside, to the Mansion House and the Bank. Unquestionably it is the most direct line between the centre of the City and the West End, and it is also the most fashionable one; but notwithstanding these circumstances, it is more interrupted, and therefore more tedious, than any of the others. It is crowded with all sorts of vehicles, varying in size and weight from coal waggons to porters' trucks; and at some times of the day it is absolutely impassable for anything like a decent carriage. If a nobleman's family, in their open Barouche, should happen to be caught in one of those interrupting crowds which defy all passage, they may be jammed up between a brewer's dray on the one hand, and a nightman or dustman's cart on the other, and compelled to wait between odours which are the very reverse of those of "Araby the blest." Meanwhile they must hear the gross language of the low and motley crowd who have charge of the vehicles by which they are thus hemmed in, and this language is repulsive to decent people of every grade in society. If they attempt to move on, their carriage has every chance of being broken, and themselves seriously injured, or it may be killed upon the spot. Even where the street is wider, and such interruptions are neither so frequent nor so perilous, the line is still disagreeable; and by some strange mismanagement in the state of things, the most inviting parts of the line are those in which the interruptions are most frequent. There are one or two good shops in the narrow part of Fleet Street, and in Ludgate Hill and Ludgate Street. But if a lady from the West End drives there, she must select her shop, and keep herself to that. She cannot walk from shop to shop with comfort, or even with safety; and though she directs that her carriage shall be drawn up ever so close to the pavement, it is liable to be injured by the public vehicles that are passing every moment. Those vehicles are a great accommodation to the body of the people, and especially to those in business, and therefore they can no more be dispensed with than can the wharfs and barges along the shores of the river. When therefore we study the case in all its bearings, we can no more dispense with the crowd on this line, than we can get rid of the vulgarity of the other two, and consequently our business is to escape to another locality, and leave the business and its accommodations to have their own way.

Different parts of the British Metropolis are called by different names, as the City, Westminster, and the several Parliamentary boroughs which have been formed out of the suburbs; but still the whole of them compose one mighty London, and the different names of the several sections do not separate them from each other any more than the different names of streets in an ordinary town. The aggregate of the whole is, as we have said, one, and the parts have reciprocating influences upon each other, in consequence of which, it is necessary for the general good that all of them should have the most free, ready, and convenient intercourse with each other, by means of appropriate thoroughfares. Of these intercourses, that between the West End and the City is of first-rate importance. The government of Britain, and all its institutions, have been nourished, and continue to be supported, by the commerce of the country, as the grand stimulus to every exertion, whatever may be the object that it seeks to accomplish. But the West End is the seat of the legislative, legal, and political government; and the City is the grand centre of commerce—the place where the sinews of war and the comforts and ornaments of peace are to be obtained. It is not desirable that these two centres of government should be in the same locality, but the intercourse between them should be as free and commodious as possible.

At present this is not the case; for the state of all the thoroughfares between the West End of the Metropolis and the East, cuts those places as completely asunder as though miles of an uninhabited common were interposed between them; and indeed it would take little more time, and be much more easy and pleasant, to cross ten miles of common than to go from Charing Cross to

the Bank in the usually crowded state of the streets. Therefore, a new thoroughfare, one which shall be of easy and uninterrupted passage, and yet not interfere with the business either of the streets or the river, is imperiously demanded, not as a matter of ornament, but as one of absolute necessity.

The line of the Thames is the most direct and appropriate one, along which to form this thoroughfare; for the Treasury may be regarded as the centre of the West End, and the Bank of England as the centre of the City; and a thoroughfare here does not deviate a great deal from the straight line joining these two centres. Accordingly, it is to the line of the Thames that every projector has turned his attention when proposing such a thoroughfare. But, though the line of the Thames has been proposed, the proposal has not been restricted to the Thames itself. In the more showy projects, the line of communication has been mixed up with architectural fancies; and to these fancies the convenience of intercourse, and the water side trade of Westminster and the City have been proposed to be sacrificed. Now, though it is desirable that every public work should be as ornamental as possible, not a tittle of convenience should be sacrificed to mere ornament: this convenience is the grand essential subject, which should be constantly kept foremost in view, and secured to the fullest extent that the circumstances of the case admit of, and the ornamenting should come in as a secondary matter, not to interfere with the principal one, but to be as tasteful as is consistent with that.

This mixing up of architectural ornament with that which has really very little to do with architecture, is not only absurd in itself, but it renders the whole scheme impracticable. So far, this impracticability is an advantage, because it prevents all the mischief that would arise from the carrying such a project into effect. The proposal is usually to have a Terrace along the bank of the Thames, wholly or partially on the land, or built up, artificially, as a piece of masonry, in the water. This is in some of the projects to be carried riverward of the wharfs, and arches are to be formed for admitting intercourse with these. But, if the proposers of such things understood the matter, they would not need to be told that in the course of a very few years the wharfs would be silted up and rendered perfectly useless. The owners of the said wharfs are, of course, aware of this, and therefore they would not permit this ornamental terrace to be built across a single one, unless full value were paid for it and the trade connected with it. Thus, supposing an Act of Parliament to be obtained, empowering the proprietors of a project of this kind to purchase such interests as might be affected by it, the costs in litigation and trials, independently of the purchase-money and the expense of doing the work, would amount to much more than the total cost of the Suspension Road.

Then, supposing the terrace completed, and the architectural somethings built upon it, what would be the ornament, and for whose delectation would it be displayed? It is difficult to conceive what kind of architectural structure would ornament about two miles of the bank of the Thames, so as to have any congruity and keeping as a whole; and then the want of utility of the several parts would make all the garnish of it absurd. But, besides this, who is to see it? Those on the promenade could not do so to any advantage, unless the said promenade were at least a hundred feet wide, and even then they could see but a scrap at a time. Passengers along the river, by oars or steam, would therefore be the principal parties to see this goodly sight, with the exception of the coal-heavers, coke-burners, and other labourers on the Surrey side of the water; and we suspect that so vitiated is the taste of these latter, that they would prefer a tankard of Barclay, Perkins, and Co. to all the architectural fancies in the world. Nothing is an ornament except to those who can get a sight of it, and as this project would have its back turned to the Metropolis, it could not well be an ornament to that. Then, as to utility, that would be of a very inferior kind, while the expense would be enormous—so great, indeed, that the half of London would have to be sold to pay for this Terrace along the Thames.

Still, a thoroughfare between the centres of the East and West, which shall not be interrupted by crowds and wagons, or annoyed by omnibusses, is urgently and imperiously demanded; and taking the case in all its bearings that the Suspension Road way properly executed, would be superior to every other,—perfectly unique, and admitting of no near approximation in the way of rivalship. The line is the shortest and most direct one; the street from its eastern terminus to the Bank might be rendered one of the neatest ornaments of the city; and there is remarkably little to be purchased—indeed, we may say nothing at all. Blackfriars bridge is already public property, and the sooner Waterloo bridge becomes the same, the better. Now the abutting of the Suspension Way on each side of one pier would save some expense, and might be made ornamental to the bridge, instead of being unsightly. This striking off of all first cost, is in itself a great matter, and might suffice to turn the scale in favour of a scheme which had equals in other respects; but when it is considered that the structure itself would, independently of all purchases, cost only a fraction of what any other kind of structure would cost, and yet be equally durable, commodious, and safe, the pecuniary argument gains double force.

In summer, the drive, the ride, or the walk, would be perfectly delightful, more especially if, as we suggested in last number, the parapets had a row of plants upon each. In winter, too, this roadway would be warmer than one on a platform, because the wind would not blow against it with such force. View the matter in whatever light we may, this proposal appears to advantage, and it should be studied by every one who is anxious to promote the welfare of the British Metropolis, and through that the welfare of Britain and of all nations. This the reason why we have taken up the subject somewhat *con amore*; and we shall return to it as occasion serves, until we have worked out the details both of the structure and of what it will cost.

"COMMON SENSE" ON SUSPENSION BRIDGES.

TO THE EDITOR.

SIR,—An article in your last number, headed "Institution of Civil Engineers," and purporting to be written by Mr. Provis, who, I believe, was resident engineer under Mr. Telford during the construction of the Menai bridge, has naturally drawn my attention to this subject. Perhaps it may be as well to premise that I am no engineer either in reality or in name, and therefore, though what I write will of course want the science and intelligence of one of the profession, it will also be free from the technicality and from whatever prejudice of theory may prevail among engineers. It has often struck me that the principles upon which engineers proceed are tabooed to the public, and as they have the expending of more public money than men of any other trade, excepting perhaps the

trade of politics, it would be highly desirable that there should stand between them and the public a sort of interpreter, who should let the latter know in a homely way what the former are doing.

It has always struck me that a suspension bridge, formed of wrought-iron chains, properly put together, and in a right position, is one of the happiest applications of material that can be made; because the iron is stronger against a pull than almost any substance with which we are acquainted, and the quantity produced in Britain is so great, and the mode of producing it is so much improved that, strength for strength, it is cheaper than wood, brick, stone, or other material of which a bridge can be constructed.

But though iron is an excellent material, and though a chain bridge is a most valuable idea, it somehow or other strikes me that the engineers do not properly understand the idea, and consequently do injustice to the material. I think that the Menai bridge, the subject of Mr. Provis's observations, together with his suggestions for the improvement of that bridge, and the observations on these and the general subject, made by several members of the Engineers' Institution, sufficiently bear me out in the conclusion that there are some principles in a chain bridge on which one and all of them seem perfectly ignorant.

Before entering on the examination of this bridge, the means which have been resorted to for the supposed strengthening of it, and the observations of the engineers upon it, and upon chain bridges generally, it is but justice to advert to what was incidentally hinted at in your number for June, namely, that the Menai bridge is placed in the most trying situation in which such a bridge can be. I do not mean with reference to the weights that pass over it, for these are equally felt, whatever may be the situation of the bridge; and the same weight that breaks down a bridge by its mere pressure in the most exposed situation, will do the same in the most sheltered one. That which has done the mischief in the case of the Menai bridge is the wind; and I very much doubt whether, notwithstanding all his talents and experience, Mr. Telford took the requisite precautions for guarding against that. It is true that Mr. Telford was not the inventor of chain bridges, but adopted the model as it had been constructed by others, only enlarging and strengthening this one in the full ratio of its superior magnitude. Thus far, therefore, he is not to be blamed. As little is he to be blamed for the casualties that ensued; for these were not known, not having happened to any other bridge; and therefore, as there was no suspicion that they would occur, there was no inducement to guard against them. Other chain bridges, in less exposed situations, and weaker in proportion to their span, had stood well, and suffered from no casualty; and, therefore, it was quite natural for the engineer to suppose that his very superior structure would be both strong and durable; and even stone bridges with arches, which have been long in use, and are familiar to every stone-mason, are still so little understood in some of their leading principles, that the engineers have to add a large quantity of materials in order to make sure of strength, which would not be at all necessary if the principles were understood. Now, if this is the case with structures of such ancient introduction as bridges with arches, much more must be the case with chain bridges, which are, as it were, but of yesterday, and which involve more new and complex principles than the arch. One difference I may mention, because it is both an obvious and a striking one, and the one, I believe, which has had the greatest tendency to mislead the engineers. If weight is applied to an arch, so to press upon it equally and not greatly alter its shape, it increases the strength of the arch; whereas, weight applied to a chain bridge is always a source of weakness, more especially if, leverage included, it presses more at one place than at others,—more if towards the centre of the chain that if it is near one of the piers or abutments; and I are inclined to think, that if it is any thing but a downward pressure, it will, in bridges of the common construction, tell most forcibly about midway between the centre and abutments.

Having premised these general remarks, I shall first consider the casualties of the Menai bridge, as stated by Mr. Provis, and then inquire why these casualties have taken place.

That there was an element of self-destruction involved in the bridge, is proved by the fact of the first casualty, which happened before the bridge was actually completed and opened as a thoroughfare. During some severe gales in December 1825, it appears that there was considerable motion in the bridge, and that the chains did not move in unison, but were thrown out of the parallel direction. This suggested the idea of introducing struts between the chains, so as to keep them equidistant; but this plan was not immediately adopted; and if it had, I do not think that it would have been of much service, because it was a mere attempt to counteract the effects of the evil, without at all reaching the cause, which is a very bungling way of going to work.

In January and February immediately following, severe gales broke some of the vertical suspending rods, and of the bearers of the roadway. The gales could have no direct tendency to break the latter; and therefore the evil must have lain in the rods, or the rods and chains jointly. The motion of the roadway was an oblique undulation, just as was to be expected from the wind, which blows in gusts, and never acts simultaneously with the same force upon such a length as the Menai bridge. The oblique vibration told on the roadway only; but if the chains and suspending rods had been closely examined, it would have been found to begin with them. The means of repair adopted here, were, like those in the former case, applied to the effect and not the cause, and I rather think that some additional causes were added. The broken bearers were suspended to the roads by stirrups, and the underside of the roadway was increased in weight by oak planks placed crosswise below and bolted to it. What effect these planks were intended to have, it is not very easy to find out; but I am inclined to think that, as a cure, they were worse than the disease Another means of repair and preservation consisted in keeping the chains equidistant by means of cast iron tubes, extended from chain to chain, and having wrought iron bolts passing through the interior openings. These repairs, it is said, preserved the bridge for ten years; but, as no part of it was weakened by wearing, the same force that injured it at the end of ten years, was just as likely to injure it at the end of ten hours; and, therefore, we may conclude that, during the ten years, there was no gale of sufficient violence for fracturing any part of the bridge.

But, in January 1836, a violent gale broke several of the rods, and the undulations appear to have been greater than on the previous occasions. On this occasion, Mr. Provis and Mr. Rhodes reported on the bridge, and their advice was that—"A greater degree of rigidity should be given to the roadways, so that they should not bend so easily under vertical pressure." Now, here I should wish to known the amount of "vertical pressure" upon the roadway of this bridge during a gale blowing with a given velocity; for, though I can understand how the lateral pressure upon chains,

injudiciously loaded toward the centre, and, through this, on the vertical suspending roads, would act, I do not understand the subject of this vertical pressure. Colonel Pasley and others say that the vertical pressure is the wind from beneath, raising up the platform. Other engineers deny this, and Mr. Provis among the rest; but still they acknowledge a vertical pressure, which does serious mischief during gales of wind, but in what it consists or how it acts they do not say; perhaps they caught up the idea in Ireland, where "an even down wind" is said to be a phenomenon that frequently occurs. But, as the wind blows upon the whole in a horizontal direction, it cannot produce a vertical pressure. In fact, the rapid motion of the air diminishes the pressure, and the barometer falls during gales of wind, therefore, any vertical pressure that can act upon the roadway of a suspension bridge, is the weight of the said roadway, and whatever strain may be communicated from the chains by means of the suspension rods. If these rods are vertical and parallel to each other, as they are in the Menai and most other chain bridges, they are liable to a good deal of strain, and that unequal, from any motion that may be communicated to the chains.

Whether any thing was done to make the roadway more rigid, and thereby lessen the vertical pressure, after the damage done by the gales in 1836, is not stated; but if any thing was done, it was by no means effectual, as in January 1839, the bridge was much more injured than upon any previous occasion. Out of 444 suspending rods, a third were rent asunder; the struts and ties intended to keep the chains parallel were broken, and much of the road was completely destroyed. Beams were now applied to stiffen the roadway, and we believe no injury has since taken place. This, however, is likely to be owing to the absence of violence in the wind, much more than to the stiffening of the roadway; but Mr. Provis adheres to the notion that longitudinal stiffness is the grand panacea for chain bridges.

Such is a brief analysis of the leading points in the paper of Mr. Provis; and I now proceed to a still more brief analysis of the observations by the other engineers. Mr. Cowper attributed the injury to the vibration of both chains and roadway; contended that if this was regular it would destroy any structure, and recommended "slight brace chains" for checking the vibration. So far as I can understand his remarks, he stated that the primary evil was in the oscillations of the chains.

Mr. Brunel advocated the application of brace chains, and observed that the chains of the Menai bridge vibrated before the platform moved; and he argued that the suspending rods were altogether too long, and that their unequal lengths in different parts of the bridge produced the undulations. A careful examination of these remarks will show that increased rigidity in the roadway increases the liability to fracture. In the Menai bridge, it was always at the roadway ends that the suspending rods were wrenched and broken, which shows pretty clearly that the injuries arise from the roadway not obeying the vibration of the chains; and this may arise either from too great a tendency in the chains to vibrate, or from too great longitudinal rigidity; but, as the vibration begins the mischief, it is to the lessening of it that the efforts of the engineer should be directed, and it does not appear that this has been attended to as it ought.

Mr. Brunel strongly recommends the brace chains, which should be fixed to the one abutment, made fast to the centre of the roadway underneath, and crossing there be carried to the other abutment, where they pass over pulleys, and are kept taught by weights of four tons suspended to each. This is the way in which Mr. Brunel proposes to give steadiness to the Clifton bridge, which is to be 700 feet span, and 200 feet above the surface of the water. Now, it does not appear that those chains will have very much effect. As each end of them will be 350 feet long, there must be a considerable curvature downwards at the middle of each; and this must be hauled taught before the chain can act as a tie. But a tie is of little value unless there is a strut answering to it, and no contrivance can convert a chain into a strut. In consequence of this, it is not easy to see how slight brace chains can be effective in preventing the vibration of such a mass of metal as the Menai or Clifton bridge, considering the vast leverage with which the central part of it acts. It appears, therefore, that the brace chains will allow the vibration to take place before they are hauled taught, or, if not, the vibration will tear them asunder; and in either case they are only a dead weight upon the bridge.

The mode in which a chain has a tendency to move, when acted upon continuously by a varying force like that of the gusts of wind during a gale, is worthy of consideration. It is not oscillation like that of a pendulum, but oscillation and undulation joined; for when one part of the chain is taken by the gust, the opposite part is tightened and raised upwards; and this undulation once begun, continues, —the chain having compound motion, consisting of lateral vibration and longitudinal oscillation; and as these are continually varying their ratio to each other, the chain twines like a serpent, within wider or narrower limits, according to the length of the chains, the depth of their curvature, and state of the weather. I know not what may be the effects of Mr. Brunel's brace chains on the Clifton bridge, but I do conceive that a score of them would not benefit the Menai bridge by the value of a single farthing. Mr. Brunel farther recommends that there should be only two main chains, and not four; and in this I think he is right.

Mr. Rendel is of opinion, that braces and stays would not prevent the motion of the roadway, and in this I think he is right. He, however, recommends stiffening the roadway by trussing both vertically and horizontally; and in this I think he is wrong, inasmuch as he merely contends against the effect without at all attacking the cause. Several other engineers made remarks both on the nature of the motions and on the trussing, but these were short and not very intelligible. All the observations made by Mr. Provis and the others, tended to show that they felt a something which they did not understand; or, in other words, that they had not studied the main principle which should guide engineers in the construction of chain bridges. A passing remark by Mr. Rendel, that there had been too much theorizing on the catenary, is to the purpose, and points out the direction in which the fault lies, though it does not reach the fault itself, or the means of avoiding it.

Where there is ignorance on the part of the leading engineers, met in solemn conclave in the theatre of their Institution, it would be presumption in me to suppose that I could fully understand the subject; for I pretend to neither science nor experience in engineering, but merely take a common-sense view, such as plain men usually take of subjects involving difficulty.

Let us therefore begin with Mr. Rendel's casual hint, and consider the catenary. This is understood to be the position of equilibrium in a rope or chain, suspended freely between two points, and assuming its form from its own weight. Now, granting, as we must in justice grant, that the catenary is the position of equilibrium for the whole chain and all the parts of it, it by no

means follows that the catenary is the best form of chain for a suspension bridge.

The position of perfect equilibrium is, from the very nature of the case, the position of perfect instability; because that which is in equilibrio is under the government of no one controlling force. It is true that, as all matter gravitates, there must be two forces in order to sustain the position of equilibrium, and those forces must be exactly equal, and exerted opposite to each other in the direction of the same straight line, and consequently in the same place with each other. They may be either simple forces, such as the force of gravitation, or they may be compound forces, the resultants of the composition of several simple ones. But, whatever they are, they must be equal, exerted opposite to each other in the same straight line, and at the same place.

Let us apply this general principle to a chain in the form of a catenary, and making part of a suspension bridge. The one force is the weight or gravitation of the chain acting in a straight line to the centre of the earth, or as it may be taken at any part of the catenary, acting in a plane coincident with this straight line, and extending the whole length of the ordinate of the chain. The opposing force which just balances this in the case of a catenary of equilibrium, is the tension or power of resistance of the chain, the different parts being resolved into a resultant which is exactly opposite to the direction of gravitation, and counteracts it; and it is perfectly evident from what has been stated, that, although these two forces produce the state of equilibrium by their opposite action, the substance is no more under the control of one of them, than it is under the control of the other; therefore, the least force applied in a direction different from these, will produce motion in the body or piece of matter.

We have a good example of this in the "logans" or rocking stones, which are yet to be met with in several parts of the country. These are large stones, balanced on edges or angles of stones under them, and admitting of some play, but not so much as to throw them off their balance. I have seen some of these several tons in weight, and yet so perfectly in equilibrio that I could make them rock with my little finger, even when I could not feel that I was giving any push whatsoever. This shows how very unstable any thing in equilibrio is against a force acting in a different plane from that to which the equilibrium is adjusted.

In as far as the centre of gravity is concerned, the axis of gravitation is constant; and the body, if taken at the centre of gravitation, admits of being freely turned round upon its axis; but, as there is not, generally speaking, any centre to the opposing force, the body does not admit of being turned upon any axis answering to that.

Let us now apply this to the catenary. The line of tension, though the resultant of it assumes a vertical form, is horizontal; and if the two abutments of a catenary are of equal height, this line of tension is at right angles to the line of gravitation. Suppose now, that, by the action of the wind or any other force, the catenary is pressed to one side,—and, because it is in equilibrio, the least force will bend it a little way in this direction. By this means the position of the line of gravitation is shifted by a small angle, whose vertex is at the centre of gravity of the earth. This is a vibration one way, and the line of tension, which has been bent from its true position, reacts, acquires some momentum in reacting, and the catenary completes its oscillation by a little advance toward that side upon which it is taken by the wind. But the oscillations are not perfect ones, extending to equal distances on both sides of the perpendicular, as is the case with the oscillations of a pendulum. The wind meets and resists the returning catenary, making the vibrations to windward much smaller than those to leeward; and if the wind is strong, and the catenary of great length and freely exposed, the whole vibrations, where the gust tells, are to leeward of the plane of still equilibrium. This produces a sort of struggle between the different parts of the chain, as well as between the force of the wind and the tendency to vibrate to windward; and the result consists of some very curious and complicated motions, such as the serpent-like twining of the chain if nothing is suspended to it, and undulations in whatever may be so suspended. If bracing, brace chains, or any other contrivances are introduced to steady that which is suspended—the roadway of a suspension bridge for instance—the result is greater contorsion of the parts; and if the chains are of great length and strength, and the wind violent, fracture of the suspending rods, and disruption of the roadway, must be the consequences. This has been the case at the Menai bridge, and though, after the roadway had been stiffened, a stronger gale was perhaps necessary to occasion disruption, yet the action, when it did come, was much more violent.

The casualties which I have now stated, are inseparable from the very nature of a chain bridge. Let us examine the circumstances by which they are likely to be increased, and those by which they are likely to be diminished.

In the first of these respects, weight at the centre will cause the chain to vibrate more readily, to a wider extent, and with more force. We may see this illustrated in the slack rope, which can be made to vibrate but little and for a short time when it is unloaded; but the dancer placed on the middle of it can keep it in wide vibration by the mere flexures of his body. Many other illustrations of this may be given, and the principle itself is easily understood. The weight at the centre of the chain or rope, has the leverage of half the length at each end, and its own gravity gives it a momentum; and it might be possible to increase these until the chain broke by the mere fact of gravitating, or till whatever were suspended to the chain were shaken off or shattered to pieces. This is the principal evil arising from the chain itself, and if it exists in a high degree, there are no means by which it can be counteracted. It is a cause, and therefore continues to act in spite of all resistance of the effect; and if its energy does not tell in the natural way—that is, as the simple result of the vibration—it will tell in some other, such as wear and tear, or fracture.

If the bridge is of very moderate span, the vibrations of the chain, though overloaded at the middle, will be but limited; and in such a bridge there will be little undulation of the roadway, or tendency to break the suspending rods, even though placed in the very worst position, that is, the vertical one. When, however, the span is very great, the vibrations correspond, and if the roadway does not act in unison with them as part of the system, the structure will give way where weakest, which experience has shown to be at the attachment of the rods to the platform; as the vibrations of the chains have the whole length of the rods as a lever power, with which to wrench them at these points of attachment. It is not at the centre of the chain that this wrenching has the greatest effect, nor is it near the abutments. In the first position, the rods afford the minimum of lever power, as compared with the whole series, and in the second, the vibrations are a minimum. The point of greatest disturbance should be midway between these;

and during the disturbance in 1836, the gate-keeper at the Menai observed, that these were the points at which the roadway was most violently disturbed.

What has now been stated, is the principal cause of damage to suspension bridges from the effect of storms; and when Mr. Brunel completes the Clifton bridge, we suspect that, in consequence of its vast span, the bridge will suffer severely; and that his trussed framing, and his brace chains, will be found to have very little effect, excepting in light gales. This, however, is upon supposition that Mr. Brunel, like all his engineering predecessors, will overload his chains in the centre, give them too much curvature, and then attempt to bolster up the errors in principle by practical patchwork, as has been done in the case of the Menai bridge.

I find no fault, and attach no blame to the engineers for their blundering in this way; for no man can do better than the extent of his knowledge enables him; and though ignorance is a ground of lamentation, is is not one of punishment. The engineers were familiar with arched bridges, in which the weakness and the strength are reversed in respect to what they are in a suspension bridge; and they could not divest themselves of notions established by long practice. The object was to get the bridge strong enough for carrying its own weight, and whatever load might pass over it, and thus far they have succeeded in almost every instance, though at a sad sacrifice of materials and money. The vibrations of the chains, and the undulations of the roadways, were matters which they appear scarcely to have taken into account; and thus they did not provide against them; and even with the experience they have had, they seem either unwilling or incapable of taking a sound and comprehensive view of these matters.

Besides the overloading at the centre, there are a few minor points which demand consideration, such as too great depth in the curve, and too great stiffness in the roadway. But most of these have already been adverted to; and so I shall now offer a few remarks respecting the avoidance of these evils.

In the first place, the curve should not be so deep as the catenary; because in that form the gravitation and tension are equal to each other. Much less should it be deeper; for that would make the tension less than the gravitation, and increase the tendency to vibrate in the same ratio. There is a difference between the two forces, however, which it is necessary to take into account: the gravitation remains the same in the same quantity of gravitating matter, whatever its position may be; but, in equal quantities of matter, the tension increases as it is brought up to the straight line between abutment and abutment; and, if the depth of the curve were made infinite, or, which is the same in effect, the chain were broken in two, the tension would be nothing. I have already said, that the catenary is the position at which these forces were equal; and, from what has been now said, it follows that, as we descend below the catenary, the tension becomes the weaker force, and still weaker as we descend deeper and deeper. But, as we rise above the catenary, the tension becomes the greater force, and greater the nearer we approach to the straight line. This must not, however, be misunderstood. When I speak of an increase of tension, I do not mean an increase of strength in the chain, but exactly the reverse. The tension is not the strength of the chain, but a force tending to pull it asunder; and, as the chain is brought up nearer to the straight line, the increase of this force makes it incapable of supporting so much weight. It appears, however, that the chains are by far the strongest part of a bridge of this kind, for in the case of the Menai bridge, they did not sustain the slightest injury from a hurricane which shattered the roadway. Therefore, it is pretty evident, that if the chains were relieved of that unnecessary weight toward the centre, which is inseparable from a chain of uniform dimensions throughout, they would bear to be brought up by a very considerable fraction of the axis of the catenary.

This will be attended with several advantages which uniform chains cannot possess, at least to such a degree. In the first place, the chain would be brought into a position of stability, because it would be under the increase of tension as a governing power. Secondly, the axis of vibration would be lessened by the whole amount of the elevation above the catenary; and this would greatly diminish the vibration itself. Thirdly, the tension is the power which reacts against a lateral impulse, such as that of a strong gust of wind; and, if we take this and the former jointly, the tendency to vibration will, even in a pretty long chain, be reduced almost to nothing; and this will be a complete security against such casualties as have befallen the Menai bridge. Fourthly, all the trussing and other matters now used—not very judiciously I think—to stiffen the roadway, and which are mere dead weights, producing weakness and not strength, might be dispensed with. Fifthly, though the roadway, and from that the chains, would be relieved of this weight, they would be stronger, and not weaker, for the relief. Sixthly, a vast quantity of materials would be saved in all parts of the bridge; and the piers reduced one-third, or perhaps one-half in height, which would diminish the expense, and also place the chains in such a position that the wind would have much less action upon them. Altogether, a bridge of this construction would be highly advantageous, both as to strength and security from accidents, and as to cost of erection.

How much, taking it in whole, it would be reduced in quantity of materials, and in expense, there are no complete data for ascertaing; it consists of many parts or items, none of which can be made out by simple calculation without experiment; and experiments in such matters are not always to be trusted. They are usually made by means of models vastly smaller than the structures that are to be erected. Independently of this, it is difficult to get them done by the proper parties, or in the proper manner. The experiments of engineers are but too frequently made, not for the purpose of obtaining such results as might turn out, but in order, if possible, to obtain some result previously desired by the experimenter; and in such a case, but small reliance can be placed on them.

There is, however, one portion of the reduction of materials, and consequently of expense, which does admit of something like calculation. Suppose the chains to be constructed in the manner invented and used by Mr. Dredge, of Bristol,—that is, beginning with a certain strength of iron at the abutments—varying according to the size and purpose of the bridge, and tapering toward the centre, until there it is only half the abutment quantity—and we shall by this means get rid of half the iron in each chain. This, however, is not all we get rid of in respect of weight; for the half dispensed with has its thick portion in the middle, and that which remains has its correspondingly thick portions at the abutments. At the middle, the lever power is a maximum; and at the abutments it is nothing. Now, if we take the average, we find that the tension of the central part is double that of the abutment parts, therefore, the iron required to support itself in a taper chain, is only one third of what it is in a chain of uniform weight throughout. This is only

one item of the quantity of metal, but it is a considerable one, and may be made more of than its simple weight thus calculated. The other items are the weight of the roadway, and that of the maximum of carriages that can pass along the bridge; and as these depend upon the span, and the purpose for which the bridge is intended, they must be found for every individual case, without any analogy drawn from other cases. It is possible, however, to throw the weight of whatever passes over upon the whole bridge, and also to propagate to the whole bridge any concussion or disturbance of the roadway, from whatever cause it may arise. This is done by means of a certain obliquity in the position of the suspending rods, and by joining them both to the chains and to the roadway, by means of eyes and bolts. When put up in this manner, all the rods act in sympathy with any one near to which a local pressure is applied; and thus this pressure is equally distributed over all the chains, which cannot be the case if the rods are vertical, and fixed either at the one extremity or the other. Not only this, but the pressure is thrown toward the strongest part of the chain, namely, toward the abutments, where there is by much the largest quantity of metal, the least leverage, and the least tension. To ascertain the total result of all this compound action, is a matter of difficulty, and needs experiment, but it unquestionably adds much to the strength of the bridge, especially as a means of transit; and, therefore, with equal strength, it allows a diminution of weight. This and the former diminution being ascertained and allowed for, we get at the necessary quantity of material, to which, however, an allowance must be added for contingencies. But, after all this—I speak at random—I am of opinion that one-half, or perhaps two-thirds or more of the usual materials and cost might be saved.

There is one other matter which I have forgotten in its proper place, and so may just mention it before I close this long and rambling letter. It is customary to pass the suspension chains over pulleys, and bring a half catenary beyond each pier into action with the chain. Now, this is not only unnecessary, but it greatly weakens the chains by making them longer, in some instances twice as long; and no countervailing advantage results from it. Therefore, the chains ought to be made fast to the abutments at each extremity, as in this case they would be more steady, and the effect of the expansion would not be greater. How these external semi-catenaries came to be used, it is not easy to say; but, like most of the other parts of chain bridges, they show a marvellous lack of knowledge on the part of the engineers—even those of them who have been justly esteemed in most other matters which they have undertaken.

Such are a few simple remarks that have occurred to me on considering the subject of chain bridges—a subject to which I am very partial, and which does not appear to be so well understood as it ought to be. If you will have the kindness to give them a place in your Journal, perhaps they may draw attention to the subject; or if not, they will at all events be in accordance with the dictates of

COMMON SENSE.

ON BRIDGES.

SIR,

THE invention of bridges was the first step towards civilization, and without them, no doubt but we should soon be as we were originally; therefore, their construction is well deserving the attention of every scientific man and journalist who aims at his country's good.

I am now induced to address you on the subject from seeing in your last Journal the opinions of a few men who stand high as engineers in this branch of mechanics, which, if suffered to pass unnoticed, will be a tacit admission that their views are well founded, and the promulgation of which may lead to incalculable mischief. Messrs. Rendel, Donkin, Brunel, and other civil engineers, have contended that heavy bodies are less liable to motion: in this they are right, but they forget that heavy bodies are less able to bear it. And according to their dogma, all that is required in suspension bridges is rigidity in the platform or horizontal line, to be obtained only by vertical or horizontal diagonal trussing, or by additional weight. This of course infers that the horizontal line is every thing in suspension bridges, and the arch to be hardly deserving even a secondary consideration: they may entertain such views, but it must be clear to every body that the arch in every bridge, be its position upwards or downwards, is as essential towards the support of the structure as the horizontal line. I conceive that they are both equally as useful in all bridges, even as much so as the muscle and bone in the human arm. If the horizontal line be of such importance in suspension bridges as they have pointed out, then how is it that it is so much neglected in stone bridges, for truth in the one must be truth in the other, as the same principle pervades both.

Oscillation, undulation, or vibration, in suspension bridges, is only motion in different directions, which originates in half of the suspended weight being balanced on the lowest point of the arch, and which multiplies directly as the length, and inversely as its depth; and consequently the whole suspended weight is easily set in motion from this cause by the slightest force in any direction. The same exists in the common stone bridge, but it is less perceptible, owing to the weight of the transit loads being so trivial in comparison with the weight of the structure. In the Menai bridge, if its suspended weight be a thousand tons, as the deflection of the arch is one fifteenth of its length, the strain on the chains at the centre is 3750 tons, but not an atom of which should be there, as that point is the extremity of two projections. And when this enormous load, which is composed of weight and leverage, is in motion so extensively as Mr. Provis has described, then no human mind can calculate the destruction to which the structure must be exposed in consequence; besides which, such a system is enormously expensive: the chains alone are about 2,000 tons weight, but they need not be more than 50 tons; the masonry need not have been more than one-fifth what it is, and the timber not more than one-third; nor does a bridge stand in need of any vertical or horizontal trussing. In short, there need be no timber used in suspension bridges, as iron and stone will answer every purpose, and these are very durable and cheap materials. What I have now stated will not long remain mere assertion, as there will be, in the course of a week or two, in the Regent's Park, practical proofs of their truth. I have now only to add that, in my opinion, the common arch, with good abutments, in architecture, or for vaults and tunnels, whether it bows upwards or downwards, when it is the segment of a circle, it is a perfect piece of mechanism, as every particle pressing against it is stationary, and is a component part of the arch, which, in fact, is self-supporting in the highest degree; but, a bridge is exposed to transit loads, which are ever destroying it; therefore, the common arch is any thing but correct or mechanical for the construction of bridges.

I am, Sir,

Your humble servant,

Bath, June 18th, 1841. J. D.

COMPETITION.—CAMBERWELL CHURCH.

It is expected that the number of competitors for the new church at Camberwell will be unusually great, the sum allowed for it (£18,000) being about equal to the cost of half a score of some of the recent buildings of the kind, whose cheapness is their sole merit, and in which no other ingenuity is displayed than that requisite for packing a congregation into the smallest possible compass. If all we have heard be, as we sincerely hope it is, correct, the committee are so anxious to secure such a design as shall be creditable to themselves and to the parish, that they have determined to be guided by the opinion of Mr. Barry, whom they have appointed as umpire and referee. Whether that gentleman has actually consented to undertake so delicate an office, is a point as to which we cannot speak; but, at all events, his being applied to for such purpose, is a tolerably plain proof that the committee are in earnest, and willing to adopt such measures as best promise the attainment of the object they profess.

As a preliminary step to all the rest, we would strongly urge the expediency of a public pre-exhibition of the designs; nor is it with us the least forcible argument in favour of such mode of proceeding, that it has never yet been adopted. Therefore, say we, by all means let it be tried—and the present opportunity for doing so seems quite as favourable as any that is likely to occur: after which, should it be found to be inefficacious, we can then but return to the old system. In our opinion, had the designs for the Taylor and Randolph Institute, at Oxford, been publicly exhibited beforehand, the choice would have been exceedingly different from what it now is, and Mr. Cockerell would never have been allowed to convert the opportunity so offered for adding another fine structure to that university, into one for displaying on a large scale the same unfortunate architectural eccentricity he had previously shown in the British Fire-Office, in the Strand. By affording an opportunity to others to behold the designs beforehand, the committee would also afford themselves the opportunity of leisurely reconnoitring them when hung up all together; and their after-labour would probably be abridged, as it would be seen that a great many were put perfectly *hors de combat*, and that it would be necessary to select for examination and discussion those drawings alone which more particularly recommended themselves, and which, however different from each other in other respects, seemed nearly on a par as to merit.

We have, indeed, heard it made an objection to the scheme of exhibiting competition designs to the public beforehand, that it would be opening the door to a great deal of manœuvering and intriguing; and that he who could best bribe or secure the good word of editors and critics would stand the best chance of succeeding. If, indeed, any individual in the profession could secure the suffrages and unanimous support of all the press, he might be able to exert very undue influence. Yet, hardly could he do so without his name transpiring abroad and being publicly bruited abroad prematurely—for no names would have been disclosed in that stage of the business; besides which, he might expose himself to a great many other awkward risks and mishaps. He might, for instance, attempt to gain over one, who, for some reason or other, might decidedly wish success to a rival party, in which case his offer would be most heroically spurned, and perhaps himself exposed. After all, too, it is not to be supposed that public opinion, whether expressed through the medium of newspapers or otherwise, would be blindly deferred to without further sifting it, and comparing together conflicting criticisms. Most certainly Mr. Barry, if he really is to be the umpire, would not suffer himself to be imposed upon or misled by mere newspaper opinions.

If the experiment of a pre-exhibition of competition designs is ever to be made at all—and until it be made it is impossible to say with certainty how far it would prove successful or not—we should advise it to be made at once. Let the Camberwell committee, then, seize the opportunity of being the first to set an example that would probably become a precedent in all future cases of the kind, and lead to that reform in such proceedings which is now greatly required.

As to one point there can be no doubt whatever, namely, that such an exhibition—which ought to be kept open for a month at at least—would excite an unusual degree of interest both among the profession and the public.

FRIENDSHIPS OF PHILOSOPHY.

We quote the following passage from the preface to the Encyclopædia Britannica Treatise on the Steam Engine, written by Mr. John Scott Russell, and now published in a separate form. We have had time merely to glance at the Treatise, but it appears to be one of the most complete and circumstantial, upon that or any similar subject. At the same time it is methodically, clearly, and luminously written; considering the number of the illustrations, it is a very cheap book, and as it explains all the modern improvements and applications, it cannot fail in being a boon which every Machinist and Engineer will receive with much gratitude. On some future occasion we shall attempt a brief analysis: and so, in the mean time, we shall only heartily recommend the book, express our gratitude to the proprietors for having had the spirit to procure this and other original treatises for their grand national work, and give the extract to which we have alluded.

We need hardly say,—for every person worth addressing on the subject knows,—that James Watt, and the late Professor Robison, were two of the greatest men that Britain ever produced; and that both of them directed their great talents to purposes of much practical utility. We need not particularise what was done by Watt, because in him was contained the original germ of all those improvements and applications of the steam-engine, of which the results may be seen everywhere both on the land and the water. But still, it was not in his individual contrivances, happy as they were, that Watt rendered so much service to the Engineering Arts. He was to this department of science what Bacon had been to science generally. He introduced the principles of sound and practical philosophy into the workshop, and thereby completely changed the characters and views of those who are engaged in machinery and engineering. By this means he delivered them out of the rut, out of that servile following of their predecessors, which was so fatal to improvement, and taught all—at least of the teachable ones—to become independent, both in thought and in action.

Robison followed a different course, his great object being to introduce practical subjects into the otherwise dry disquisitions of speculative philosophy. His treatises, especially those in the

former editions and supplements of the Encyclopædia Britannica, were the first models which we had in Britain of this kind of writing, in which the profound views of the Philosopher are combined with the practical skill of the Engineer.

Following out such different views of the same subject, which, notwithstanding their difference, conduced to one great practical result, they were far more useful than if they had been fellow-labourers in any one department; and when we come to contemplate the immense improvement of machinery, and the vast advantages which that improvement has bestowed and is bestowing upon mankind, it is not always easy to say for how much of the impulse we are indebted to Watt or to Robison. The fountains which they opened will continue to flow in perennial streams, brightening and broadening as their courses extend, until the benefit shall have reached the uttermost parts of the earth; but the union between what was done by these great men, will remain as fast as their friendship in life, of which the following extracts afford very delightful evidence:—

In the joint lives and labours of Robison and Watt, we open one of the brightest pages of the "friendships of philosophy"—intellectual prowess was in them remarkably conjoined with the virtues and amiabilities of social life, and it is difficult to say, whether we more admire the philosopher, or love the man. Akin to these feelings appear to have been the sentiments with which, through a long life, they regarded each other. Fortunately, the records of these sentiments still exist in notices written by themselves. Robison's sketch of Watt is already before the public; but we have now the pleasure of presenting to our readers a companion sketch of Robison, drawn by Watt himself, which we owe to the kindness of Sir John Robison, and which, in April 1805, was addressed by Watt to the widow of the departed friend of his youth.

Mr. Watt's Sketch of Dr. Robison.

"Our acquaintance began in 1756-7, (Mr. Robison being then 17,) when I was employed by the University of Glasgow to repair and put in order some astronomical instruments, bequeathed to the University by Dr. Macfarlane, of Jamaica. Mr. Robison was then a very handsome young man, and rather younger than me. He introduced himself to me, and I was happy to find in him a person who was so much better informed on mathematical and philosophical subjects than I was, and who, while he was extremely communicative, possessed a very clear method of explaining his ideas. Between two young men of ardent minds, engaged in similar pursuits, a friendship was soon formed, which has continued until death has deprived me of my friend, and has suffered no other interruption than what has been caused by our absence from each other, and the necessary attention to our respective duties in life. Soon after this, I settled as mathematical instrument maker in the college of Glasgow, and was favoured with Mr. Robison's company until he left the college about the end of 1758, and went to sea—I believe in one of his Majesty's ships.

"During this period, he turned my attention to the steam engine, a machine of which I was very ignorant, and suggested that it might be applied to giving motion to wheel carriages, and that for that purpose it would be most convenient to place the cylinder with its open end downwards, to avoid the necessity of using a working beam. The latter idea he had published some time before in the *Universal Magazine*.—In consequence, I began a model with two cylinders, of tin plate, to act alternately by means of a * * * acting on two pinions attached to the axes of the wheels of the carriage; but the model being slightly and inaccurately made, did not answer expectation. New difficulties presented themselves; both Mr. Robison and myself had other avocations requiring our attention, and neither of us having then any idea of the true principles of the machine, the scheme was dropped. I, however, went on with some detached experiments on steam, until 1763, when I set about the matter more seriously, and discovered the principles upon which my improvements on the steam engine were founded."

Beside this we place the following extract from the Eloge of Watt; being—

Dr. Robison's Sketch of Young Watt in his Workshop.

"When I was as yet a young student, I had the vanity to think myself a pretty good proficient in my favourite studies of mathematical and mechanical philosophy, and on being introduced to Watt, was rather mortified at finding him so much my superior. Whenever any of us stumbled on a difficulty, we went to Watt; he needed but to be prompted; every thing became to him the beginning of a new and serious study, and we knew that he would not quit it till he had either discovered its insignificancy, or made something of it. . . . On one occasion, the solution of a problem seemed to require the perusal of Leupold's Theatrum Machinarum—and Watt forthwith learned German; at another time, and for a similar reason, he made himself master of Italian. . . . When, to the superiority of knowledge which every man confessed, is added the *naive* simplicity and candour of Mr. Watt's character, it is no wonder that the attachment of his acquaintance was strong. I have seen something of the world, and am obliged to say, I never saw another such instance of general and cordial attachment to a person whom all acknowledged to be their superior. But this superiority was veiled under the most amiable candour and liberal allowance of merit to every man—Mr. Watt was the first to ascribe to the ingenuity of a friend, things which were very often but his own surmises, followed out and embodied by another. I am well entitled to say this, having often experienced it in my own case."

Below this sketch Mr. Arago has written a note, to which we shall every one subscribe:—"It is difficult to determine whether the honour of having uttered these last words is not as great as that of having inspired them"—and, with both sketches before us, we are equally left in doubt whether each were not fully entitled to all the encomiums his friendship has passed on the companion of his youth, and the unchanged friend of his declining age.

BRIDGES, ANCIENT AND MODERN.

(*Continued from page* 116.)

Roman Bridges.—Whatever doubtful circumstances attend the claim to the invention of the arch, we know, from the best historical evidence, that the Romans first applied it to works of general use, as in forming aqueducts for conveying water to large cities, constructing bridges over rivers, vaulting magnificent temples, and in erecting monuments for recording the actions of their greatest heroes.

We at present consider only their bridges. At or adjacent to Rome, Gautier mentions eight bridges.

1. Pons Ælius, built by the Emperor Adrian, and named after him. It is said to have once had a cover of bronze, supported by 42 columns. It is now called Sancto Angelo.

2. A triumphal bridge, the ruins of which are now seen in the Tiber. The emperor and consuls passed over this bridge when they were decreed a triumph.

3. Pons Janiculensis, now Ponto Sixtus, it having been rebuilt by Pope Sixtus IV. in 1475.

4. Pons Cestius, at present St. Bartholomew. It was rebuilt by the Emperor Valentinian.

5. Pons Fabricius, now Ponto Caspi.

6. Pons Senatorius, at present Sancta Maria.

7. Pons Horatius, formerly Sublicius, built of stone by Horatius Cocles; rebuilt by Emilius Lepidus; the ruins are still seen in the Tiber.

8. Pons Milvius, which is about two miles out of Rome, upon the Flaminian way.

Palladio gives a description of the bridge of Rimini, built by the Romans also on the Flaminian way, which has five arches; likewise that of Vicenza upon the Bachliglione, of three arches; and of one upon the Rerone, of three arches.

And Martinellis mentions a bridge near Narni, on the road from Rome to Loretto, built by Augustus. It consisted of four arches, the first 75 feet span and 102 high: the spans of the others were 135, 114, and 142 feet. This appears to be the most magnificent bridge the Romans constructed in Italy.

In the provinces the Romans built many bridges, some very magnificent. We shall instance two in Spain, both in the province of Estremadura. That of Merida is upon the river Guadiana. Don Antonio Ponz, in his *Viage de Espnd*, says he found its length 1300 paces; Vargas reckons 64 arches. In the time of Philip III. one of the large arches towards the middle was destroyed by an inundation, on which account three or four adjoining were rebuilt in 1610.

But perhaps the most magnificent of all the Roman bridges, and one of the noblest monuments of antiquity, is, the bridge of Alcantara upon the Tagus, at the town of that name. The town has probably taken its name from that structure, as the word *alcantara*, in the Arabic, signifies a bridge. It consists of six arches: its whole length is 670 Spanish feet, and from the bottom of the river to the roadway the height is 205 feet.

MODERN BRIDGES.—When the arts began to revive in Europe, it was chiefly towards religious structures that power and influence were directed. One singular instance occurs of enthusiasm being directed to the useful purposes of improving the passages over rivers. Gautier, upon the authority of Magna Agricola of Aix, says, that upon the decline of the second, and commencement of the third race of kings, the state fell into anarchy; and that there was no security for travellers, particularly in passing rivers, where violent exactions were made by banditti. To put a stop to these disorders, sundry persons formed themselves into fraternities, which became a religious order, under the title of Brothers of the Bridge. The object of this institution was to build bridges, establish ferry boats, and receive travellers in their hospitals on the shores of rivers. The first establishment was upon the Durance, at a dangerous place named Maupas; but in consequence of the accommodation arising from this establishment, the same place acquired the name of Bonpas. He relates further, that St. Benezet, who proposed and directed the building of the bridge of Avignon, was a shepherd, and that he was not twelve years of age when repeated revelations from Heaven commanded him to quit his flock and undertake this enterprize; that he arrived at Avignon just at the time the bishop was preaching to fortify the minds of the people against an eclipse of the sun, which was to happen the same day. Benezet raised his voice in the church, and said he was come to build a bridge. His proposition was accepted by the people with applause, but rejected with contempt by the magistrates, and by those who thought themselves wisest. As it was at that time an act of piety to build bridges, and Avignon being then a popular republic, the people prevailed, and every one contributed to the good work, some by money, and some by labour, all under the direction of Benezet, aided by the brothers. And he, by performing a great number of miracles, animated the zeal of every body. Upon the third pier was erected a chapel to St. Nicholas, protector of those who navigate rivers. This was done after the death of Benezet, which happened in 1184. His tomb became celebrated for pilgrimages, where many miracles were performed. He had taken care to establish a conventual house, and a hospital, leaving the brothers to continue the work of the bridge.

This bridge, which was composed of 18 arches, was begun in 1176, and completed in 1188. In 1385, during the contentions of the Popes, some of its arches were destroyed: three others fell in 1602, from the neglect of repairing a fallen arch. In 1670, the frost was so great that the Rhone for several weeks bore the heaviest carriages: when the thaw followed, the ice destroyed the piers; but the third pier, with the chapel of St. Nicholas, has stood notwithstanding all these accidents.

Our admirable bridge saint, not the least useful of that once numerous class of enthusiasts, in accomplishing, under such circumstances, so difficult, valuable, and magnificent a work as the bridge of Avignon, has perhaps quite as just a claim to the power of performing miracles as most of the saints of his day; and it is not improbable, that from the influence of his tomb, and that of his mantle upon the surviving brethren, that the still greater bridges of Lyons of 20 arches, and St. Esprit of 19, were accomplished.

Perronet states, that in 1354 an arch of 150 French feet, or 160 English feet span, was built at Verona; and in 1454, one of 172 French feet, or 183.8 English span, and 66 French feet, or 70.6 English of rise from the springing, at Vielle-Brioude, upon the river Allier in France. The last-mentioned is the greatest span we know of for a stone arch.

In Italy, there are many fine bridges. The peculiar situation of Venice has required a number far beyond what is to be found in any other city. The finest is the Rialto of 98½ feet span, and 23 feet rise. It was designed by the celebrated Michael Angelo, and erected between 1588 and 1591.

In France, during the two last centuries, many fine bridges have been erected. The Pont Royal over the Seine at Paris, in 1685, from a design of Mansard. It consists of five arches. The centre one 77 French, or 82.3 English feet span; the breadth, including parapets, 56 French, or 59.9 English feet. The bridge at Blois, built from a design of the Sieur Gabriel, consists of 11 arches; the centre one 86 French, or 91.10 English feet span; the breadth over the parapets, 50 French, or 53.5 English feet.

Perronet gives plans and descriptions of sundry large bridges in France, constructed between the years 1750 and 1772.

The first in point of time and magnitude is the new bridge upon the Loire, at Orleans. The ancient bridge, which consisted of 19 arches, was in so bad a state, that it was found necessary to construct a new one; for which a design, made by M. Hupeau, then first engineer of bridges, was preferred; and by that time such was the progress made in bridge building, that, instead of 19 arches, as in the old edifice, this new design consisted of only nine. The middle arch is 100 French, or 106.9 English feet span, and the rise or versed sine 28 French, or 29.11 English feet. The arches next the abutments are 92 French, or 98.3 English feet span, and rise 25 French, or 26.8 English feet: the others are in proportion. The breadth, including the parapets, 46 French, or 49.2 English feet. It was begun in 1750, and opened to the public in 1760. Nothing can exceed the simplicity and elegance of this bridge.

Of the same beautiful simplicity of character is the design of the bridge upon the river Seine, at Mantes. It consists of three arches: the middle arch is 120 feet French, or 128.2 English feet span, and rise 36 French, or 38.5 English feet; the two side arches are 108 French, or 115.4 English feet span, and rise 32 feet 6 inches French, or 34.9 English feet. It was also designed by M. Hupeau; begun under his direction in 1757; and during that and 1758, raised to the level of the sixth course of arch stones: the work was then suspended on account of a war. It was recommenced in 1763 under the direction of Perronet, (M. Hupeau having died in that interval,) and was opened in 1765.

One of the finest of the French bridges, and the greatest work of Perronet, is that upon the Seine at Neuilly. It consists of five arches, each 120 French, or 128.2 English feet span, and 30 French, or 32 English feet rise; the breadth, including the parapets, is 45 French, or 48 English feet. It was begun in April 1768, and opened in October 1773; the masonry was completed in 1774: the roads, and other operations connected with this bridge, were finished in 1780. A great peculiarity in this bridge, well deserving the attention of engineers employed in similar works, is, that the soffits of the arches are shaped to suit the contracted vein of water, as formed in the entrance and exit of pipes. This is accomplished by making the general form of the body of the arch elliptical, with a rise of 30 French, or 32 English feet, or ⅓ of the span; but making the headers follow the segment of a circle, the versed sine of which is only 13½ French, or 14.5 English feet, or about ⅛ of the span. This, besides affording facility for the passage of flood waters, gives a great appearance of lightness to the whole fabric.

In the bridges at Orleans, Mantes, and Neuilly, we find the rise of the arches to be between ⅛ and ¼ of the span; but rendered confident by success, and desirous of giving a variety to his works, Perronet, in the bridge over the Oise, at St. Maxence, consisting of three arches, each 72 French, or 76.10 English feet span, makes the rise only 6 French, or 6.5 English feet, or $\frac{1}{12}$ part of the span; also, instead of making the piers each a solid, right lined on the sides, he divides each pier into two distinct parts, with an open space between them, and composes each part of two columns united by a piece of plain wall. The deviation from former works of a similar kind is here certainly sufficiently distinct; but the propriety of this measure will be discussed under the head of Practice. This bridge was begun in 1774; the operations were suspended in 1775; they were recommenced in 1780; and the centers were struck in 1785.

The bridge built upon one of the arms of the Loire at Saumur, from a design of M. de Voglio, and executed chiefly under the inspection of L. A. de Cessart, may also be classed amongst the first of the French bridges. It consists of 12 elliptical arches, each 60 feet span, and 21 of rise; the piers are 12 feet thick, and the breadth of the bridge, including the parapets, is 42 French, or 44.9 English feet. It was begun in 1756, and finished in 1770.

INSTITUTION OF CIVIL ENGINEERS.

ON THE PROPERTIES AND CHEMICAL CONSTITUTION OF COAL, WITH REMARKS ON THE METHODS OF INCREASING ITS CALORIFIC EFFECT, AND PREVENTING THE LOSS WHICH OCCURS DURING ITS COMBUSTION.—BY CHARLES HOOD, F.R.A.S., &c.

The Properties and Chemical Constitution of Coal.—It appears that, previous even to the invasion of the Romans, coal was used as a fuel in Great Britain; but such was the prejudice against it, that wood was the fuel generally in use among the higher classes until the eighteenth century, when the supply of it diminished so considerably as to render necessary the substitution of coal; and from that time the increase in its consumption has been immense.

Previously to the seventeenth century, the smelting of iron and all other metals was performed by charcoal; but the attempts of Sturtevant and Ravenson, in 1612-13, and of Dudley in 1619, to introduce the use of coal or coke in blast furnaces, having proved the possibility of success, the progress of the innovation, though slow, was certain, and led to the transfer of the iron works from many of the original positions in the midst of forests, to the coal districts where they are now placed.

The author considers his subject under three heads:—1st—The chemical character and composition of coal; 2ndly, its properties as a combustible; and 3rdly, the nature and application of its various gaseous products.

The Chemical Character of Coal.—1st. The opinion that coal is a com-

pound of carbon and bitumen has been objected to by some chemists, on the ground that by no process hitherto pursued in analyses has it been possible to resolve it entirely into these two substances; even at a low temperature, a quantity of gaseous matter is thrown off, and at an elevated degree of heat, an evident decomposition takes place. Even anthracite contains a small portion of volatile matter, its component parts being carbon, oxygen, hydrogen, and nitrogen, which exists in a gaseous state in the pores of the coal. In bituminous coal, the hydrogen is combined with a larger proportion of oxygen and nitrogen: the mechanical difference being, that the bituminous and free burning coals (more particularly) melt by heat when the bitumen reaches the boiling point, whereas, anthracite is not fusible, nor will it change its form, until it is exposed to a much higher degree of temperature.

Two tables of the analyses of different coals are given from the authorities of Mushett, Thomson, Vanuxem, Daniells, Ure, and Reynault: No. 1, showing the proportions of carbon, ashes, and volatile matter, with the specific gravity of the coal and the coke; and No. 2, showing the proportions of carbon, hydrogen, azote, and oxygen. These tables show that the largest quantity of carbon (92·87) is contained in the Kilkenny anthracite, and the least quantity (64·72) in cannel coal; and that the nature of the volatile matter greatly affects the quantity of coke—the aggregate quantity of the gaseous products of coking, splint, and cherry coal being very nearly similar; while the quantity of coke obtained from these different species varies more than 45 per cent.

The author then points out the continual presence of azote, which quits the base with the greatest difficulty; and also the affinity of sulphur, not only for the coal, but for the coke, as it is rarely found to have been completely expelled even from the most perfectly made coke; the only coal found to be even partially free from it being anthracite, in some species of which no traces of its presence are found.

The Combustion of Coal.—2dly. The application of coal as a fuel depends on the chemical change which it undergoes in uniting by the agency of heat with some body for which it possesses a powerful affinity. In all ordinary cases, this effect is produced by its union with oxygen. When coal is entirely consumed, the carbon is wholly converted into carbonic acid gas and carbonic oxide, and the hydrogen into water, in a state of vapour. The atmosphere supplies the necessary oxygen for this purpose; and in this state the products of the combination are nearly or quite invisible, both of them being almost colourless fluids; if, therefore, any smoke be visible, it is the result of imperfect combustion. Some calculations are given to ascertain the amount of loss that is sustained when the smoke escapes unconsumed; from which it appears, that with bituminous coal, about 37 or 38 per cent. more heat is produced when the smoke is consumed, than when it escapes freely. Many modes of consuming smoke have been attempted; those which appear to have been attended with the greatest success, are, 1st, Causing the smoke from the fresh coals to pass through or over that portion of the fuel which is more perfectly ignited; 2ndly, Supplying heated air to the top of the fuel, as well as admitting cold air through the ash-pit in the usual manner; and 3rdly, Throwing a jet of steam into the furnace, or into the chimney. The various modes of carrying into effect these plans are briefly alluded to; from them a few may be selected. Robertson's plan was to use inclined furnace bars, where the fresh coals were placed close to the fire-door, and being there partially carbonized, gave out the gas which, in passing over the mass of incandescent fuel, was ignited, and became active flame, thus economizing fuel, and preventing smoke. In this and similar cases, by the slow distillation of the coal, a gas is produced, which not only inflames at a lower temperature than the dense olefiant gas produced by rapid distillation, but which only requires for its combustion a quantity of oxygen, never exceeding double its own volume, or ten times its bulk of atmospheric air, while olefiant gas requires three times its own volume of oxygen, or fifteen times its bulk of atmospheric air. The elimination of a gas which burns with so small a portion of oxygen, is, therefore, the principal cause of the non-production of smoke in furnaces of this description. The second mode of consuming smoke is founded on the necessity which exists for a large supply of air being requisite to inflame the gases given off from coal by a rapid and intense heat; and this is accomplished by introducing a quantity of heated air above the burning fuel. When a quantity of fuel is thrown into a furnace, the increased thickness of the mass opposes additional resistance to the passage of air through the bars; the temperature of the furnace is lowered, and an increased volume of gas is at the same time given out. If at this moment a quantity of air, heated to the temperature of the gas, be admitted, the gas immediately inflames, and that which would have produced a dense black smoke, passes off in the invisible state of carbonic acid gas and vapour of water. Different gases require different degrees of heat to inflame them; and this explains the easy combustibility of the volatile products of coal, when the heat is so managed as to produce those gases which inflame at the lowest temperature. A larger quantity of air is required at the time that the coal is first thrown on, than at a subsequent period; therefore, when economy is studied, the supply of air should be gradually diminished as the mass approaches an incandescent state. The use of heated air has produced most important results in the manufacture of iron with bituminous coal, and also with anthracite; the latter fuel having been almost neglected until the recent application of this principle of employing heated air to promote its combustion, although it is known to be capable of producing perhaps a more intense heat than any other carbonaceous fuel. The rationale of the third plan, of consuming smoke by injecting a jet of steam into the fire or the chimney, is less obvious than the others. In 1805, Mr. Davies Gilbert observed, that whenever the waste steam of one of Trevithick's engines was permitted to escape into the chimney, the smoke from the coal was rendered invisible. Subsequent experiments confirmed this fact; and it was supposed, that the steam being decomposed furnished oxygen to support combustion. The author combats this opinion, and accounts for the effect by the increased draught of the furnace, caused by the jet of steam in the chimney, by which means a larger portion of air is brought into contact with the burning fuel; thus supplying the previous deficiency of oxygen to the fire, and promoting the combustion. As steam is only about half the weight of air at a like temperature, and the power of all gaseous fluids to ascend is "*inversely* as the square roots of their specific gravities," the velocity of its escape by the chimney, compared with common air of the same temperature, is about as 1·4 to 1; therefore, the compound mixture of steam, air, and carbonic acid gas, will escape with a considerably increased velocity, and more air must consequently enter the furnace. It appears that about 10 per cent. of the total quantity of steam generated is necessary to effect the combustion of the smoke by this means; therefore, unless the waste steam only be used, the saving of the fuel must be reduced by this amount. Brief mention is made of the experiments of Messrs. Apsley Pellatt, Parkes, and the Chevalier de Pambour, proving that a given quantity of oven coke will produce as much heat as the coal from which it was produced; and of the various kinds of artificial fuels which have been invented, especially that produced of resin and peat coke, of which the author remarks that its combustion probably produces a mechanical effect, as the hydrogen is converted into water in a state of vapour, which escapes through the chimney with a great velocity, and consequently a large quantity of air is drawn into the furnace, and a more perfect combustion of the fuel is the result. In the same manner he accounts for the necessity which exists for having the openings between the bars wider in a furnace in which coke is burned than in one used for coal. In opposition to the general opinion, he considers that less air is required for the consumption of coke than for coal; the carbon only requiring 2½ times its weight of oxygen for its combustion, while the hydrogen contained in coal requires 8 times its weight of oxygen: and the only reason that the openings between the bars are required to be wider in the former than in the latter case, is in consequence of the draught being so much slower during the combustion of coke.

3dly. "On the nature and application of the volatile products of coal." In treating this portion of the subject—many of the observations on which have been necessarily anticipated in the preceding sections—the author traces the application of carburetted hydrogen gas to the purposes of artificial illumination from the year 1798, when its first successful application was made by Murdock at Soho: he then proceeds to Dr. Henry's investigations of the phenomena of its production and combustion; the variation of the intensity of light obtained from carburetted hydrogen, due to the proportion of carbon contained in it; the difference in the gas obtained from the different qualities of coal; the superiority of the illuminating power of the gas from cannel coal; and the still greater power of that produced from the decomposition of oil, which is 2 to 2½ times greater than that of coal gas. He then mentions the other products of oil by distillation, such as ammoniacal liquor, carbonic acid and oxide, sulphuretted hydrogen, tar, essential oil, naptha, petroleum, asphaltum, and other substances. The paper concludes by pointing out the advantages which would result from the production of such gas as is usually given out at the beginning of the distillation of coal, as it contains two volumes of gaseous carbon united with two volumes of hydrogen, and its illuminating power is consequently more than double that of ordinary coal gas.

Mr. Parkes observed, that the quantities of air required for the combustion of different fuels as determined in the laboratory and on the large scale of practice, were frequently very different. It might be quite correct that a given weight of coal would require more air for its perfect combustion than the same weight of coke. There was great difficulty in ascertaining the fact practically, under steam-boilers, as the gases given out by the coal must have air supplied to them distinct from that which passed through the grate to ensure their perfect ignition, and many cir-

cumstances prevented the consumption of air from being exactly measured. Generally, he had found it necessary to use wider spaces between the grate bars for coke than for coal. In some late experiments very carefully made on a boiler invented by Mr. A. M. Perkins, equal weights of coal and coke required the same time for their destruction on the same grate, the apertures of the damper and ash-pit door, which were used to govern the draught, being precisely the same. Coke effected a greater evaporation than coal at similar rapid and slow rates of combustion; and in every case the temperature of an oil bath at the foot of the chimney was higher with coke than with coal. It must, however, be remarked, that no process had been used to ignite the gases which escaped from the furnace uninflamed. He had tried different kinds of coke, coal, and anthracite at this boiler, and the same fuel in every instance performed a greater evaporative effect at a slow than at a rapid rate of combustion. He thought that much of the air which entered the grate of a boiler passed through the fire unconsumed, for want of time to effect a sufficiently intimate combination with the fuel. In some experiments lately made at Swansea on the properties of anthracite, Dr. Schafœutl had found from analysis, that no less than 40 per cent. of the products of combustion taken from the chimney consisted of oxygen, yet he had effected the large evaporation of 11 lbs. of water with 1 lb. of that fuel.

Mr. Field stated, that Mr. Cooper had expressed an opinion that in the use of coke as a fuel, a less portion of heat reached the chimney than with coal, on account of the large quantity of unconsumed air that passed through the fire, owing to the open spaces necessarily existing between the pieces of such a dry fuel as coke; whereas in a fire made of binding coal, nearly the whole of the air combined with the fuel in its passage through the body of fire.

Mr. Pellatt observed, that although in practice coke appeared to require more air to support combustion than coal did, yet long experience had taught him to believe that when coal was exposed to a rapid combustion, it required more air than coke.

In answer to an observation that some experiments lately made on the measurement of the quantity of air which entered the blast furnaces of Sir John Guest at the Dowlais Iron Works might bear on this subject—Mr. Farey objected to the application of such results to determine the question, as the air is injected with considerable force into a furnace; there is frequently a great reflux of blast from the tuyere when the furnace is working close; whereas when it is working open, the flame at the top shows that the passage of the air through the mass of burning fuel is very free, and that consequently a portion of it passes off unconsumed. He had found in his experiments on blast furnaces, that unless there was a redundancy of carbon, and a deficiency of oxygen, there was no chance of making good iron.

EXPORTATION OF MACHINES.

(*Continued from page* 118.)

The complement to these facts may be found by referring to the monthly list of new patents taken out in France and Belgium, of which one-third, at least, are by Englishmen, for inventions or improvements already patented on this side the water. The title once secured, the patentee makes the best of it, either by sale or by association; but in all cases he engages to carry it out on his own responsibility. Not permitted to get his machinery from home, he is forced to instruct workmen to make it abroad; and thus the injury done to us is twofold. But who will blame a man so circumstanced? His invention is, probably, the only fruit of a life of labour, and a fortune spent in repeated experiments. It is vain to expect such men to sacrifice their future prospects of hard-earned riches to satisfy a stupid monopoly; to compel them to do so is impossible. Repeal the law, and we shall have all the profits of a valuable export trade. Machinery, no doubt, will go abroad, but the vital spirit of it—the skill and cunning of our inventors, will remain with us to fructify new schemes, to bring forth, from the inexhaustible stores of human genius, still finer combinations of positive science, to enrich and adorn our beloved country.

The prohibition on machinery is operating as a premium to foreign machinists to excel us in the mechanic arts—our pride, our glory, and our strength; the pure source of so much honour and profit, and unquestionably one of the chief causes of the moral influence that we exercise in the political councils of the great family of Europe.

It has been strangely asked, "Would it not be wiser, instead of abolishing the law, to make it general and absolute, by prohibiting the exportation of every description of machinery, not excepting the steam engine, as well as re-enacting the law to forbid the emigration of artisans?" This would be legislating with a vengeance, and yet who will deny that such measures, however extreme or obnoxious, would be more consistent than the practice by which we are governed? Such a remedy, however, is too violent, and comes too late: instead of diminishing, it would increase the evil. We might by violent measures frighten back some of our artisans, but the tools and models would remain; whilst no means in the power of man would stop the smuggling out of every new invention. No; there is no help for us but the prompt and total abolition of the law, which would arrest the progress of machine-making in other countries, and draw to ourselves this invaluable trade.

The total value of machinery on the continent of Europe alone, used in the manufacture of cotton, wool, flax, lace, net, and which the English are forbidden by law to export, is upwards of *fifteen millions sterling*. If we have five per cent. of this amount for renewal of old machinery, and another five per cent. as the probable augmentation of trade in that part of the world, we shall have the sum of *fifteen hundred thousand pounds sterling* as the value of machines annually made on the continent in ordinary times; two-thirds of which, or machinery to the value of *a million sterling*, would be ordered from this country, if not forbidden by the law.

Flax spinning in those countries is only now getting into importance. Six Joint Stock Companies for this object, with a capital of sixteen million of francs, have established themselves in Belgium alone since 1836. The quantity of flax made, and still making, by these Companies, is eighty thousand spindles, at a cost of more than two hundred thousand pounds. Clever workmen, and the most improved machines to serve as models, have been obtained from England, and flax-machine-making on a large scale is organized at Ghent, Bruges, Malines, Brussels, and Liege. These makers, besides supplying the country, export largely to other parts of the continent. The amount of flax machinery alone, made in Belgium, under the direction of Englishmen, and from English models, cannot be estimated at less than *one hundred thousand pounds* per annum; and certainly not a spindle for flax spinning would have been made out of England, but for the law under consideration.

The first bobbin-net lace machine was smuggled out of England for a Nottingham man, and taken to Calais in 1820. Several English mechanics escaped at the same time. This machine served as the first model; and thus lace and lace-machine-making commenced in France. In 1826 the number of machines had increased to five hundred, chiefly what are called circular bolt machines. Up to that period the weaving, as well as the making of the machinery, was almost exclusively in the hands of English operatives, whose wages averaged seventy shillings per week.

In 1830 the number of machines was increased to twelve hundred, while the number of Englishmen employed in them had proportionably decreased. In 1838 the number of looms was eighteen hundred, most of them much wider and very superior in principle to the circular bolt in use up to 1830. All these new machines were made by French mechanics, from improved models sent from Nottingham. The number of Englishmen at present employed in lace and lace-machine-making in France is comparatively small.

The wages of the people employed in this branch of trade have also decreased in an extraordinary degree. The price of weaving a rack of lace has fallen from half-a-crown to three-halfpence. The price of looms has also varied greatly, at different periods, from eight hundred to one hundred and fifty pounds each. The average price at present in France is two hundred and forty pounds.

If we take the whole number of lace looms made in France since 1820 at 2400, and the value of each machine at *three hundred pounds*, we have the sum total of *seven hundred and twenty thousand pounds*. If from this sum *one hundred and forty-four thousand pounds*, or 20 per cent., be deducted as the value of the material, there remains *five hundred and seventy-six thousand pounds* paid for the labour of making lace machinery in France, in the short period of eighteen years. Why was not this enormous sum brought to our own country, and distributed amongst our own workmen? Why have they been deprived of all the comforts and conveniences that might have been purchased by so large an addition to their earnings?

Would the exportation of lace looms have been detrimental to lace manufacturers in this country? Most decidedly not. Lace machines made in France are little, if at all, inferior to the best Nottinghamshire made looms. A good workman would weave as many racks in a given time upon the one as the other. The advantanges which English lace manufacturers possess over their French competitors are of a more sterling and inalienable kind, secured to them by cheaper yarn, cheaper machinery and repairs, light and coals, and, above all, superior, very superior, workmen; add to these the resources derived from an immense export trade.

Has the introduction of lace machinery into France diminished our exports of lace net to that country? Certainly not; but very much the reverse. It has been the sole cause, the only possible means of getting our net into that country. Lace net has always been, and still continues to be, a prohibited article; and, previous to the introduction of machinery for making it, no lace could be smuggled in, because of the impossibility of avoiding detection. The smuggling of this article has gone on increasing with the number of machines made there. Ninety-nine lace manufacturers in France out of every hundred purchase looms for no other purpose than to serve as a cloak to a contraband trade.

In 1834 the total consumption of lace net in France was estimated, by the Director General of Customs, at *twenty-five millions of francs* annually; of which, according to his estimate, *two-thirds*, or upwards of *six hundred thousand pounds* sterling value, *was lace smuggled in from England*. The remaining one-third was woven in France from English yarns, equally smuggled into the country. Here is no exaggeration, no colouring for the purpose of making out a plausible case; but a plain, honest statement of facts, that any one may verify by referring to tome iii. *De l'enquête de la Commission Supérieure de Paris: article Lainages et Cotons.*

These facts are beyond dispute or doubt; they are all-important to the present question. They prove, to a demostration, how nugatory are prohibitory laws when opposed to the material wants and necessities of any considerable portion of the community. The attempt to prohibit the introduction of cotton yarns and lace net into France has been attended with an enormous expense, while it has engendered a mass of corruption and crime difficult to conceive, and not to be contemplated without feelings of strong abhorrence for a system that fattens on the depravity it creates. The same system, the same vice, the same total failure, exists in England with regard to the exportation of machinery. We see that machinery and artisans were taken out of the country in spite of the zealous watchfulness of the Customs. The history of the bobbin-net trade in France, and the fiscal difficulties it has had to contend against in two kingdoms, might be a lesson for future practice, if men would read, mark, learn, and inwardly digest.

It may, perhaps, be argued—"that it does not necessarily follow, because lace machinery has been established in France without detriment to the manufactures of this country, all other kinds of machines can, or ought to be classed in the same category." To this I am about to reply, and I hope I shall convince a great many, that manufacturers have nothing to fear from the abolition of the law, while the exportation of machines may be immensely beneficial to the country, by increasing its internal prosperity.

A great deal too much consequence is given to the nominal price of labour on the continent. There is much less difference, in reality, than is generally imagined. For my own part, I am convinced from long experience and a close examination of the prices given for work done, that the money paid for the whole of the labour consumed in producing a piece of printed calico, a piece of broad cloth, or a piece of Irish linen, is considerably greater in France and Belgium, and somewhat greater in the most favoured parts of Switzerland and Saxony, than it is in England.

Time is cheap on the continent, but production is dear. A spinner, for example, will sell twelve hours of his labour for two or three francs, but the quantity and quality of what he will give you in return will be in the same inferior proportion, compared with the price and production of an English spinner. This fact is common to every branch of manufactures. The tact and intelligence of our workmen, and the superior excellence of every thing they produce, is the wonder and admiration of all foreigners. Whether it be a spinner at his wheels, a turner at his lathe, or a puddler at his furnace, the same extraordinary superiority over foreign workmen exists, and probably always will. The very respectable manufacturers who gave evidence before the Superior Commission of Inquiry at Paris, were unanimous in the expression of this fact, and they made use of it to prove their own inability to compete with us in third markets, or even in their own, unless protected by prohibitory duties.

It must not be supposed that, with machines equal to our own, they are able to make as much of them. It is well known they do not. There is no lack of the best Manchester and Leeds-made machinery on the continent for spinning cotton, woollen, worsted, and flax yarns; and I defy any one to show that those machines are working with as much effect as they would do either in Lancashire or Yorkshire. I know from experience that they work at a very reduced speed, require more piecers, more attendance, and consequently make more waste than is customary in the worst conducted mills in England. In all cases abroad, it requires a much greater number of hands to do the same quantity of work.

An English workman, having charge of a difficult machine, will study its parts, and soon become master of its movements. He will keep it in excellent working condition, and frequently suggest improvements. He almost invariably tries to augment its speed, and so render it more productive. This peculiarity in our national character is stimulated in the intelligent working classes by the certainty of reward, and a noble ambition to rise in the world. How many splendid examples may be cited of our workmen raising themselves to enviable distinction and honourably acquired wealth, by their talents and persevering energies! How many living examples have we, of men who have emancipated themselves from the trammels of unfavoured birth and neglected education, to take their station in society where moral worth and high intelligence are patented qualifications for admiration and esteem!

The great mass of continental workmen have neither pride nor ambition; or if they have, it is directed to other pursuits unfavourable to the peaceful occupations of civilized life. We might inquire amongst them in vain for a Smeaton, an Arkwright, a Watt, or a Telford. We should be told of Massena, Murat, and other chiefs, who have raised themselves to vain-glorious renown, not as the benefactors, but as the destroyers of their kind.

Throughout the whole of the continent, and France and Belgium in particular, youth is forcibly demoralized, in the outset of life, by the operation of the law of conscription. Young men are dragged from their homes before they have acquired fixed habits of industry. Apprenticeships, the best guardian of the morals, and the only school for learning thoroughly the arts and mysteries of a craft, are impossible, since all are liable to be called under arms at eighteen years of age. Besides, the social condition of the lower classes is the most humiliating that can well be imagined. Ignorant in the extreme; possessing no political rights, no consideration in the commonwealth; used and abused as the beasts of burden of the State; despised and feared by the pretentious classes above them; half soldier, half workman; can we be surprised if they have little taste for the study of things which their military education and their degraded position have unfitted them to understand?

(To be continued.)

AMERICAN LOCOMOTIVES.

Statement of the performance of the Locomotive Engine "Hichens and Harrison," built by Messrs. Baldwin, Vail, and Hufty, for the Philadelphia and Reading Railway.

On February 9, 1841, the above engine hauled over the Philadelphia and Reading Railway, 54½ miles in length from Reading to its intersection with the Columbia Railway, a train of *one hundred and five* loaded burden cars, laden with 1,318 barrels of flour, 870 kegs, nails and spikes, 635 bushels grain, 63 tons of blooms and bar irons, 10 cords wood, 8 casks oil, and sundry other articles of freight, amounting in all to 308½ tons of 2,240 lbs.

Weight of the 105 cars 173 tons, making a total gross weight of 481½ tons of 2,240 lbs., equal to *one million seventy-eight thousand five hundred and sixty pounds* hauled by the engine, not including her own or her tender's weight.

Cars all four-wheeled, wheels three feet diameter, lard and tallow only used in boxes. Whole length of train 1,260 feet (or 60 feet less than one-fourth of a mile).

Running time 4 hours 54 minutes, making an average speed of 11 1/10 miles an hour.

Total quantity of fuel consumed, 2.51 cords of oak wood.

Total quantity of water evaporated, 1,804 gallons.

Oil used by engine and tender, 7 quarts, including oiling before starting; longest continuous level over which the above train was hauled, 9 1/10 miles. Her speed with the train on this level, 10 8/10 miles per hour.

Weight of engine empty, 23,250lbs. With water and fuel 26,710lbs. Weight on driving wheels, with water, fuel, and two men, 14,120. Cylinders, 12½ by 16 inches stroke; driving-wheels 4 feet diameter.

The above road has no *ascending* grade from Reading towards Philadelphia, with the exception of half a mile at its lower terminus or intersection with the Columbia Railway, graded at 26½ feet per mile, on which grade the train was stopped.

The profile of the road from Reading to this point is divided into levels varying from 1,600 feet to 9 8/10 miles in length, and *descending* grades of from one and a half to 19 feet per mile, the latter being the heaviest grade on the road.

Total length of level line between above points 27 miles and 8-10ths.

Total fall from where the train was started to where it was stopped near the Columbia Railway, 214 feet.

Shortest radius of curvature on the road, 819 feet; 1,480 feet of curve struck with this radius.

The engine started the above train on a level, without any assistance, and gradually increased her speed to the average rate above stated. She worked with great ease to herself during the whole trip; and hauled the train for the last 14 miles, 10 of which were level, over rails in very bad order, owing to a light snow storm which moistened without wetting their surface; the effects of which in diminishing the adhesion and power of the engine, practical engineers can well understand and appreciate. The above performance is believed to be unsurpassed; and the train to be the longest and heaviest ever hauled by ONE engine on any railway in Great Britain or America.

G. A. NICOLLS,
Superintendent Trans. Phila. & Reading, R. R.

MISCELLANEOUS.

LIGHTHOUSE ON THE GOODWIN SANDS.—It is satisfactory to state that that great national undertaking, a fixed lighthouse on the Goodwin Sands, is now in progress, under the management and patent of Mr. W. Bush, civil engineer. It is Mr. Bush's intention, in the erection of this light, to float and sink iron caissons of from 30 to 50 feet diameter, and to excavate the sand from the internal part of the caisson by means of air-chambers, until he arrives at the chalk rock, in order to obtain a permanent and solid foundation. These caissons will be filled with concrete and masonry work, and upon this base a column of about 140 feet high, for the lighthouse, will be raised. A number of men are now at work at Deal preparing the first caisson, and before the equinoctial gales come on we understand that there is every probability of securing a solid and permanent base.

IMPORTANT INVENTION.—The *Commerce* states, that M. Jules Guillemin, of Avesnes, the engineer and director of the coal mines at Gilly, near Charleroi, has just invented a simple and ingenious plan to supersede the use of flat hemp ropes, so heavy and expensive, at present used for drawing up heavy tubs of water or coal. The ordinary machinery serves perfectly well for the new material, which is composed of sheet iron sufficiently protected against the rust. The sheet iron roller will cost fifteen times less than a hemp rope, and not weigh so heavy. M. Guillemin has obtained a patent for his plan, which will not fail to be universally adopted in coal mines, when experience shall have sanctioned the superiority of these iron rollers.

RAILROADS IN GERMANY.—The *Frankfort Journal* states, that it is in contemplation to construct four different lines of railroads, to commence at Breslau. The first is already commenced. It will lead from Breslau to Ohlan, and thence to Oppeln, 14 German miles. Secondly, a line from Breslau to Schweidnitz, in Freiburg: the vicinity of the Silesian mountains, so rich in minerals, it is considered will cause much traffic on this line. Thirdly, a line from Breslau to Frankfort upon the Oder: Prince Kolorath and other proprietors of Silesia are to have the management of this line. Fourthly, a line from Breslau through Leignitz and Gorlitz to Dresden: the merchants of Breslau are particularly interested in the completion of this line. The execution of it will, however, be attended with some difficulty.

GREAT WESTERN LOCOMOTIVES.—We understand that Messrs. George and John Rennie have sent a locomotive, the *Mazeppa*, on the Great Western Railway, which seems to contain a great improvement in its heating powers. On Wednesday it took a load of 13 carriages between London and Chippenham, a distance of 93 miles, in 3 hours 43 minutes, or in three hours travelling time, exclusive of stoppages, that is, at the rate of 31 miles per hour, and consumed only 30 to 34 lbs. of coke per mile. Some of the other engines, we are informed, use 60 to 64 lbs., and the average is estimated at about 40 lbs. The saving, therefore, if the Rennie consumption should continue, is about 14 per cent., no insignificant item in the half-yearly account.—*Railway Magazine.*

NEW ANTHRACITE COLLIERY.—In our last we noticed the opening of a new anthracite colliery on the line of the Llanelly Railway. The following account is from a correspondent:—On Tuesday se'nnight, we saw one of those successful results of science which distinguish our times, and create an epoch in the history of the locality which may have the good fortune of being the witness of the achievement. On the day named, there were brought down the Cwm Amman Railway to this port upwards of 100 tons of as fine anthracite coal as ever was shipped, and far superior to anything shipped here before. It is the first product of an extensive field of that coal now opened, under the direction of Mr. R. Hopkins, by the Gwaun-cae-gurwen Anthracite Company. What constitutes the achievement may be found in the fact that this large field of splendid coal, which is raised to the top of a mountain some twenty miles off, has been easily brought to this port by the united aid of railway and steam. Without the aid of some such auxiliaries, the whole of the valuable minerals in that extensive district would have been rendered entirely without value, by the expense of transit. Under all the circumstances of the case, the inhabitants of this rising port naturally view the occurrence of Tuesday with no small amount of gratification, inasmuch as it must prove a source of profit to them, as well as to those who may be more immediately concerned in the success of that colliery. The high sheriff of the county of Glamorgan, (J. Martin, Esq.,) John Jones, Esq., — Price, Esq., and several other gentlemen, came down with the train. A band of music was in attendance. It appears that anthracite coal is rapidly increasing in demand; its uses are greater as its extensive capabilities are developed. One fact forcibly presents itself to notice in relation to economy, and which is, the total absence of sulphur. By its existence in bituminous coal, and its liberation during combustion, we have one of the elements of sulphuric acid, (oil of vitriol,) which is so destructive to boilers; the purity, therefore, of anthracite coal cannot be an insignificant feature in its recommendation.—*Cambrian.*

PRINCESS ROYAL.—A few days since the *Princess Royal*, the new steam-vessel which is propelled by the Archimedean screw, made her first trip, with a party of the shareholders and their friends, from the Pier-head. She started at half-past nine for Littlehampton, and then steamed up the river to Arundel, where the party, in number about sixty, stopped to dine, and afterwards returned last night to the Pier, at about nine o'clock. We copy the following account of the vessel from the *Newcastle Journal*:—Length of keel of vessel 81 feet, breadth of beam 17½ feet, depth of hold 10 feet, of immersion 6½ feet, tonnage 101 register tons. Engines—two, each 23 horse power. Screw—five feet diameter: six feet pitch, 34 strokes of engine making 170 revolutions of screw, being the regulated speed. The result of several experiments with the boat on the Tyne, loaded with 24 tons of ballast, was that 34 strokes of the engine, which gives a velocity of eleven and a half miles an hour to the screw, propelled the boat eight knots, or nine and a quarter miles an hour; thus realizing an effect of fully 4-5ths of the velocity of the screw, and equal to that of the best Government steamers with paddles.—*Brighton Gazette.*

WOOD PAVING.—Slowly, but certainly, are the Metropolitan Company proceeding with their paving, upon the principle of the Count de Lisle, and, if not so speedily as the public desire, no doubt the fault is with the prejudiced, or ignorant, among the local authorities, and not with the spirited managers of the only efficient mode of paving carriage-ways with wood. The eastern part of St. Paul's churchyard will be proceeded with immediately, being the third specimen in the city; and we understand that Piccadilly is expected to be under hand in August, at least from St. James's-street eastward to Bolton-street westward. If it be true, as we have heard, that Mr. Johnson, the eminent and opulent pavior, has undertaken the practical direction of this concern, we think the last lingerings of prejudice must dissolve before the conviction that the most experienced and successful engineer in this department of public work, would not have joined in such an undertaking but with a certainty as to the beneficial results that must be derived, both to the public and to the contractors.

SMOKE ANNOYANCE.—The Court of Common Council of the City of London have determined upon taking steps to remedy the great and increasing nuisance of the smoke from furnaces and steam-engines in the city, and from steam-boats on the river. A committee has been appointed for the purposes of considering what measures can be adopted for abating the nuisance, and they have by public advertisement requested communications on the subject from scientific and practical men. Did the combustion of smoke from furnaces involve expense, or any impediment to the free use of furnaces, the question might become extremely difficult, how far such interference were justifiable in a country where manufactures form so important a part of the national prosperity. But no such difficulty can arise. The combustion of the smoke of furnaces must be a measure equally advantageous to the manufacturer as to the public; for a great saving of fuel must result by an efficient mode of consuming smoke. The vast increase in the consumption of coal in London, from the enormous number of steam-engines both on land and on the river, renders this subject daily of more importance; and it is remarkable how very little the cause of smoke is understood, and still less the facility with which remedies may be adopted. In another part of our journal will be found an abstract of a paper lately read before the Institution of Civil Engineers, by Charles Hood, Esq., F. R. A. S., on the chemical properties of coal. The entire paper is now published in a separate form: it contains much

practical information on the combustion of smoke, and may be consulted with advantage by all who wish for information on this subject.

Removal of Sunderland Lighthouse.—At a late meeting of the commissioners of the river Wear, the taking down of the lighthouse being discussed, as part of the plan of building the new north pier at the mouth of the harbour, Mr. Murray, the engineer, suggested the removal of the lighthouse, in its present entire state, to the eastern extremity of the new pier, a distance of about 420 feet, so as to make it serve the double purpose of a stationary and a tide light. Mr. Murray exhibited a model of the building, and after explaining how he proposed to effect this undertaking, the board decided that he should proceed forthwith to remove it. This lighthouse was erected about 40 years ago, by the late Mr. Pickernell, then engineer to the harbour commissioners. It is wholly composed of stone; its form is octagonal, 15 feet in breadth across its base, 62 feet in height from the surface of the pier to the top of the cornice, where it is 9 feet in breadth across, and the top of the dome is 16 feet above the cornice, making a total height of 78 feet; and its calculated weight is 250 tons. Mr. Murray intends to cut through the masonry near its foundation, and insert whole timbers, one after another, through the building, and extended 7 feet beyond it. Above and at right angles to them, another tier of timbers is to be inserted in like manner, so as to make the cradle or base a square of 29 feet; and this cradle is to be supported upon bearers, with about 250 wheels of 6 inches diameter, intended to traverse on six lines of railway to be laid on the new pier for that purpose. The shaft of the lighthouse is to be tied together with bands, and its eight sides are to be supported with timber braces from the cradle upwards to the cornice. The cradle is to be drawn and pushed forward by powerful screws, along the railways above mentioned, on the principle of Morton's patent slip for the repairing of vessels. However surprising the removal of such a building may appear to many, yet in New York, for some years past, large houses have been removed from their original situation to a considerable distance, without sustaining any injury. The immense block of granite, serving as the pedestal of the equestrian statue of Peter the Great, at St. Petersburgh, was conveyed four miles by land, and thirteen by water. Several obelisks have likewise been transported at different times from Egypt to Europe; and lately, one was conveyed from Thebes, and erected by the French at Paris. But the fact that the lighthouse on our North Pier is composed of stones of comparatively small dimensions, its great height, and small base, make the operation of removing it much more difficult than anything of the sort ever attempted. We heartily wish the enterprising engineer every success in his bold and novel undertaking, which is to be carried into execution in the course of a few weeks from this date.—*Sunderland Herald.*

LIST OF PATENTS,

Continued from page 120.

(SIX MONTHS FOR ENROLMENT.)

George Bent Ollivant and Adam Howard, of Manchester, millwrights, for "certain improvements in cylindrical printing machinery for printing calicoes and other fabrics, and in the apparatus connected therewith, which is also applicable to other useful purposes."—Sealed June 5.

John Mee, of Leicester, framesmith, for "improvements in the manufacture of looped fabrics."—Sealed June 5.

William Hannis Taylor, of Lambeth, esq., for "certain improvements in propelling machinery."—Sealed June 5.

Goseph Gibbs, of the Oval, Kennington, civil engineer, for "certain improvements in roads and railways, and in the means of propelling carriages thereon."—Sealed June 5.

Miles Berry, of Chancery Lane, patent agent, for "certain improvements in machinery or apparatus for ruling paper," being a communication.—Sealed June 5.

James Colley March, of Barnstaple, surgeon, for "certain improved means of producing heat from the combustion of certain kinds of fuel."—Sealed June 8.

Henry Richardson Fanshaw the younger, of Hatfield Street, Christ Church, Surrey, chemist, for "improvements in curing hides and skins, and in tanning, washing, and cleaning hides, skins, and other matters."—Sealed June 10.

John George Bodmer, of Manchester, engineer, for "improvements in machinery for propelling vessels on water, parts of which improvements apply also to steam engines to be employed on land."—Sealed June 10.

Edward Hammond Bentall, of Heybridge, Essex, iron founder, for "certain improvements in ploughs."—Sealed June 10.

Robert Oram, of Salford, engineer, for "certain improvements in hydraulic presses."—Sealed June 12.

James Wills Wayte, of the Morning Advertiser Office, Fleet Street, engineer, for "certain improvements in machinery or apparatus for letter-press printing."—Sealed June 12.

John Anthony Tielens, of Fenchurch Street, merchant, for "improvements in machinery or apparatus for knitting," being a communication.—Sealed June 12.

George Claudius Ash, of Broad Street, Golden Square, for "improvements in apparatus for fastening candles in candlesticks."—Sealed June 12.

Edward Palmer, of Newgate Street, gent., for "improvements in producing printing surfaces, and in the printing China pottery ware, music, maps, and portraits."—Sealed June 12.

Ezekiel Jones, of Stockport, mechanic, "for certain improvements in machinery for preparing, stubbing, roving, spinning, and doubling cotton, silk, wool, worsted, flax, and other fibrous substances."—Sealed June 12.

Alexander Horatio Simpson, of New Palace Yard, Westminster, gent., Peter Hunter Irvin, and Thomas Eugene Irvin, both of Charles Street, Hatton Garden, philosophical instrument makers, for "an improved mode of producing light, and of manufacturing apparatus for the diffusion of light."—Sealed June 17.

Thomas Walker, of North Shields, engineer, for "improvements in steam engines."—Sealed June 18.

William Petrie, of Croydon, gent., for "improvements in obtaining mechanical power, which are also applicable for obtaining rapid motion."—Sealed June 19.

John Haughton, of Liverpool, clerk, master of arts, for "improvements in the method of affixing certain labels."—Sealed June 19.

John Henry Shaw, of Charlotte Street, Blackfriars, jeweller, for "improvements in setting wheat and other seeds."—Sealed June 19.

Sir Samuel Brown, knight, of Netherbyers House, in the county of Berwick, for "improvements in the means of drawing or moving carriages and other machines along inclined planes, railways, and other roads, and for drawing or propelling vessels in canals, rivers, and other navigable waters."—Sealed June 19.

John George Truscott Campbell, of Lambeth Hill, Upper Thames Street, grocer, for "improvements in propelling vessels."—Sealed June 19.

Joseph Ganci, of North Crescent, Bedford Square, artist, and Alexander Bain, of Wigmore Street, Cavendish Square, mechanist, for "improvements in inkstands and inkholders."—Sealed June 21.

William Walker the elder, of Standish Street, Liverpool, watch finisher, for "an improvement or improvements in the manufacture of the detached lever watch."—Sealed June 23.

Robert Stephenson, of Great George Street, Westminster, civil engineer, for "certain improvements in the arrrangement and combination of the parts of steam engines of the sort commonly called locomotive engines."—Sealed June 23.

John Godwin, of Cumberland Street, Hackney Road, piano-forte maker, for "an improved construction of piano-fortes of certain descriptions."—Sealed June 23.

James Sidebottom, of Waterside, Derby, manufacturer, "for certain improvements in machinery or apparatus for preparing cotton and other fibrous substances for spinning."—Sealed June 23.

William Chesterman, of Burford, gent., for "improvements in filtering liquids."—Sealed June 23.

George Thomas Day, of Upper Belgrave Place, Pimlico, gent., for "an improved apparatus for creating draught, applicable to chimneys and other purposes."—Sealed June 23.

John Henry Le Keux, of Southampton Street, Pentonville, engraver, for "an improvement in line engraving, and in producing impressions from them."—Sealed June 23.

Miles Berry, of Chancery Lane, patent agent, for "a new or improved engine, machine, or apparatus, for producing or obtaining motive power by means of gases or vapours produced by combustion," being a communication.—Sealed June 23.

John Lee Stevens, of King Edward Street, Southwark, general agent, and John King, of College Hill, London, printer, for "certain improvements in candlesticks and other candle holders."